# Extension of Containers Terminal at Tripoli Port (ECTTP)

## Volume 02 - B: Technical Specifications

PL241087 December 2024

Dar.com

# VOLUME 02 - B

# TECHNICAL SPECIFICATIONS

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# *TECHNICAL SPECIFICATIONS*

# SECTION 600 - SITE CLEARING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. "Drawings and general provisions of the Contract, including General and Particular Conditions, Procedures, Manuals and Specifications, including without limitation Division 1 Sections, apply to this Section".

### 1.2 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing, and removing site utilities or abandoning site utilities in place.
7. Temporary erosion and sedimentation control measures.

### 1.3 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack (less than 1 percent) of organic matter and few soil organisms.

B. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil; but in disturbed areas such as urban environments, the surface soil can be subsoil.

C. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow. Its appearance is generally friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 50 mm in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

D. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected prior to, and during construction, and indicated on Drawings.

E. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected prior to, and during construction, and indicated on Drawings and defined by a circle concentric with each tree with a radius 1.5 times the diameter of the drip line unless otherwise indicated.

F. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

G. Utilities: Underground pipes, conduits, ducts and cables, including manholes, chambers, tanks and other underground appurtenances: above ground utility structures, poles lines, services and the likes.

H. Erosion: The wearing away of the ground surface as a result of the movement of wind or water.

## 1.4 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1. Review methods and procedures related to site clearing including, but not limited to, the following:

a. Review geotechnical report.
b. Discuss existing utilities and subsurface conditions.
c. Review coordination with temporary controls and protections.

## 1.5 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, services and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or video recordings.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

C. Topsoil stripping and stockpiling program.

D. Rock stockpiling program.

## 1.6 QUALITY ASSURANCE

A. "Product, Material and Equipment shall demonstrate compliance with requirements specified in Section 016000 "Product Requirements".

B. Topsoil Stripping and Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

C. Rock Stockpiling Program: Prepare a written program to systematically demonstrate the ability of personnel to properly follow procedures and handle materials and equipment during the Work. Include dimensioned diagrams for placement and protection of stockpiles.

## 1.7 FIELD/PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Engineer and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by the Engineer or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining the Employer’s property will be obtained by the Employer before award of Contract.

C. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated or directed to remain in place. Restore damaged improvements to their original condition, to the satisfaction of the Engineer.

D. Do not proceed with work on adjoining property until directed by the Engineer.

E. A No Objection Certificate (N.O.C) shall be obtained from the concerned authorities prior to the start of any clearing and grubbing works.

F. Salvable Improvements: Carefully remove items indicated to be salvaged and store on the Employer premises where indicated.

G. Utility Locator Service: Notify utility locator for area where Project is located before site clearing.

H. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.

I. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

J. Do not direct vehicle or equipment exhaust towards protection zones.

K. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

L. Soil Stripping, Handling, and Stockpiling: Perform only when the topsoil is dry or slightly moist.

M. Stumps and roots shall be removed from the soil to a depth of not less than 300 mm below the surface of the ground in the area to be occupied by the building.

N. Wood forms that have been used in placing concrete, if within the ground or between foundation fills and the ground, shall be removed before a building is occupied or used for any purpose.

O. Before completion, loose or casual wood shall be removed from direct contact with the ground under the building.

## PART 2 - PRODUCTS

### 2.1 MATERIALS

A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 601 "Earth Moving."

1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

B. Antirust Coating: Fast-curing, lead- and chromate-free, self-curing, universal modified-alkyd primer complying with MPI #79, Alkyd Anticorrosive Metal Primer or SSPC-Paint 20 or SSPC-Paint 29 zinc-rich coating.

1. Use coating with a VOC content of 420 $Kg/m^3$ or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## PART 3 - EXECUTION

### 3.1 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated or directed to be stockpiled or otherwise remain the Employer’s property, cleared materials shall become the Contractor's property and shall be removed from Project site.

### 3.2 PREPARATION

A. Protect and maintain benchmarks and survey control points from disturbance during construction.

B. Locate and clearly identify trees, shrubs, and other vegetation to remain or to be relocated. Flag or Wrap a 25 mm blue vinyl tie tape flag around each tree trunk at 1400 mm above the ground.

C. Protect existing structures, utilities, sidewalks, pavements and other facilities on or adjacent to the site, including existing site improvements and features to remain from damage during construction.

1. Promptly repair and restore damaged improvements to their original condition, as acceptable to the Engineer.

D. The ground surface shall be prepared to receive fill by removing vegetation, noncomplying fill, topsoil and other unsuitable materials, and scarifying the ground to provide a bond with the fill material.

### 3.3 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Provide temporary erosion and sedimentation control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.

B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.

C. Inspect, maintain, and repair temporary erosion- and sedimentation-control measures during construction until permanent vegetation has been established.

D. Remove temporary erosion and sedimentation control measures and restore and stabilize areas disturbed during removal.

E. The faces of cut and fill slopes shall be prepared and maintained to control erosion. This control shall be permitted to consist of effective planting.

F. Erosion control measures need not be provided on cut slopes not subject to erosion due to the erosion-resistant character of the materials.

G. Erosion control for the slopes shall be installed as soon as practicable and prior to calling for final inspection.

## 3.4 TREE AND PLANT PROTECTION

A. General: Protect trees and plants remaining on-site according to requirements.

B. Repair or replace trees, shrubs, and other vegetation indicated to remain or to be relocated that are damaged by construction operations, in a manner approved by the Engineer.

1. Submit details of proposed repairs.
2. Replace trees and shrubs that cannot, as determined by the Engineer, be repaired and restored to full-growth status

## 3.5 EXISTING UTILITIES

A. Locate, identify, disconnect, and seal or cap existing utilities indicated to be removed or abandoned in place.

1. Arrange with utility companies to shut off indicated utilities.

B. Locate, identify, and disconnect utilities indicated to be abandoned in place. Use proper scanning machine to detect utilities locations and excavate trial pits as needed using manual tool only so as not to disturb or damage any underground utilities.

C. Interrupting Existing Utilities: Do not interrupt or interfere with utilities serving facilities on the site or on adjoining properties unless permitted by the Engineer under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Engineer’s written permission.

D. Excavate for and remove underground utilities indicated to be removed.

E. Temporarily or permanently re-route or re-locate existing utilities as necessary to facilitate new construction.

F. Removal of underground utilities is included in earthwork sections and with applicable fire suppression, plumbing, HVAC, electrical, communications, electronic safety and security and utilities sections, specifications sections on Structure Demolition" and "Pavement Demolishing”. .

## 3.6 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Completely remove stumps, roots and other debris.
3. Grind down stumps and remove roots, obstructions, and debris to a depth of 450 mm below exposed subgrade**.**
4. Use only hand methods for grubbing within protection zones.
5. Chip removed tree branches and stockpile in areas approved by the Engineer or dispose of off-site.

B. Cleared and grubbed material shall not be left in or under embankments or other constructed facility. All removed materials shall be disposed of at locations outside the right-of-way and not visible from the roadway.

C. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 200 mm, and compact each layer to a density equal to adjacent original ground.

## 3.7 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil to depth indicated on Drawings or to depth of 150 mm in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and non-soil materials from topsoil, including clay lumps, stones, gravel, and other objects larger than 50 mm in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 1800 mm.
2. Do not stockpile topsoil within protection zones.
3. Dispose of surplus topsoil. Surplus topsoil is that which exceeds quantity indicated to be stockpiled or reused.
4. Stockpile surplus topsoil to allow for respreading deeper topsoil.

## 3.8 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
2. Paint cut ends of steel reinforcement in concrete to remain with two coats of antirust coating, following coating manufacturer's written instructions. Keep paint off surfaces that will remain exposed.

## 3.9 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off the Employer’s property.

B. Separate recyclable materials produced during site clearing from other unrecyclable materials. Store or stockpile without intermixing with other materials and transport them to recycling facilities. Do not interfere with another Project work.

C. Waste materials shall be removed in a manner that prevents injury or damage to persons, adjoining properties and public rights-of-way.

D. Disposal of removed materials at public and private sites away from the right of way shall be done at the Contractors sole expense, in accordance with all laws and regulations, after an agreement with the property owner or public agency has been fully executed.

END OF SECTION 600

# SECTION 601 - EARTH MOVING

## 601: 1 - GENERAL

### 601: 1 - SUMMARY

A. Section Includes:

1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses, and plants.
2. Excavating and backfilling for buildings and structures.
3. Subsurface drainage backfill for walls and trenches.
4. Excavating and backfilling trenches for utilities and pits for buried utility structures.
5. Excavating well hole to accommodate elevator-cylinder assembly.

### 601: 2 - DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.

1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.

F. Fill: Soil materials used to raise existing grades.

G. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

H. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

I. Embankment: Soil materials used to raise existing grades under roadways and vehicular pavements.

J. Top 600 mm Embankment: 600 mm depth of soil immediately underneath the Subgrade Layer defined below.

K. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase of minimum depth equal 200mm.

L. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

M. Drainage Blanket: Course of washed granular material placed to cut off upward capillary flow of pore water under paved areas.

N. Drainage Course: Aggregate layer supporting the slab-on-grade that also minimizes upward capillary flow of pore water.

O. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

601: 3 - SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.
2. Laboratory compaction curve according to ASTM D 1557.

C. Preexcavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

601: 4 - QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

B. Preexcavation Conference: Conduct a conference at Project site.

601: 5 - PROJECT CONDITIONS

A. Project Site Information: Sub-surface site investigation report has been prepared for the Project area and is available for information only. The Contractor is entirely responsible for his own assessment, interpretation, use and conclusions drawn from the information data, tests analyses and opinions contained in the reports.

B. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without written permission from the Engineer and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by the Engineer or authorities having jurisdiction.

C. Improvements on Adjoining Property: Authority for performing earth moving indicated on property adjoining Employer’s property will be obtained by the Employer before award of Contract.

1. Do not proceed with work on adjoining property without Engineer’s written approval.

2. Notify the Engineer not less than two days in advance of the date of commencement of work on adjoining property.

D. Utility Locator Service: Notify authorities having jurisdiction for area where Project is located before beginning earth moving operations.

E. The following practices are prohibited within protection zones:

1. Storage of construction materials, debris, or excavated material.
2. Parking vehicles or equipment.
3. Foot traffic.
4. Erection of sheds or structures.
5. Impoundment of water.
6. Excavation or other digging unless otherwise indicated.
7. Attachment of signs to or wrapping materials around trees or plants unless otherwise indicated.

F. Do not direct vehicle or equipment exhaust towards protection zones.

G. Prohibit heat sources, flames, ignition sources, and smoking within or near protection zones.

## 601: 2 - PRODUCTS

### 601:2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.

B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D 2487or Groups A-1, A-2-4, A-2-5, and A-3 according to AASHTO M 145, or a combination of these groups; free of rock or gravel larger than (75 mm) in any dimension, debris, waste, vegetation, organic matter and other deleterious matter and meeting the below additional requirements.
1. Liquid Limit: ≤ 25%
2. Plasticity Index: ≤ 10%
3. Organic Matter: 2% Maximum
4. Passing from sieve No. 200 (0.075 mm): 18% Maximum
5. Maximum Size: Not more than one third thickness of compaction placement layer.
6. The material shall be non-aggressive with water soluble Chlorides content less than 0.05%, water-soluble Sulphates (SO4) content less than 0.15%, Water soluble salt content of 5% Maximum, and pH between 6.5 and 8, when tested according to BS EN 1744-1 standards.
7. Maximum Dry Density: Not less than 1.7; AASHTO T-180 (Method D)
8. 4-day soaked CBR: ≥8%; (AASHTO T-193) when compacted at 100% max. dry density in accordance with AASHTO T-180 (Method D), except for the top 60cm of the embankment which should have a CBR of not less than 15% at 100% compaction MDD.

C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D 2487 or Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7 according to AASHTO M 145, or a combination of these groups.

1. Unsatisfactory soils also include satisfactory soils not maintained within 2 percent of optimum moisture content at time of compaction.

D. Structural backfill material: Satisfactory soil materials, and shall also conform to the following:

1. Plasticity Index: Max. of 6

2. Minimum D10 value: 1 mm.

E. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; meeting the requirements of Section 602.

F. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; meeting the requirements of Section 603.

G. Subgrade material: shall consist of selected material having a 4-day soaked CBR of not less than 20% when tested in accordance with AASHTO T 193 when compacted at 100% of modified proctor AASHTO (T-180) and having a maximum P.I. of 10%. Sub-grade gradation shall be reasonably smooth without gap grading. All material shall pass 75 mm sieve and not more than 18% shall pass 0.075 mm (No. 200) sieve.

H. Engineered Fill: the material shall satisfy the following requirements:

1. Shall be Gravel, crushed gravel and crushed stone and shall consist of hard, durable particles, free from dirt, organic matters, shale and other deleterious materials, and shall not contain more than 5% of clay lumps and friable particles.
2. The material passing No. 40 sieve shall have LL (liquid limit) ≤ 25% and PI (plasticity index) ≤ 6%.

3. The material shall conform to the following gradation:

| Sieve Designation | Percent by weight passing |
|---|---|
| 50 mm (2 inch) | 100 |
| 37.5 mm (1 ½ inch) | 95-100 |
| 25 mm (1 inch) | 70 - 95 |
| 19 mm (3/4 inch) | 55-85 |
| 9.5 mm (3/8 inch) | 40-70 |
| 4.75 mm (No.4) | 30-60 |
| 2.00 mm (No.10) | 20-45 |
| 0.425 mm (No.40) | 15-30 |
| 0.075 mm (No.200) | 5-10 |

I. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; ASTM D 2940; except with 100 percent passing a (25-mm) sieve and not more than 8 percent passing a No. 200 (0.075-mm) sieve.

J. Filter Material: Narrowly graded mixture of natural or crushed gravel, or crushed stone and natural sand; ASTM D 448; coarse-aggregate grading Size 67; with 100 percent passing a (25-mm) sieve and 0 to 5 percent passing a No. 4 (4.75-mm) sieve.

K. Drainage Course: Narrowly graded mixture of washed crushed stone or crushed or uncrushed gravel; ASTM D448; coarse-aggregate grading Size 57; with 100 percent passing a 37.5 mm sieve and 0 to 5 percent passing a No. 8 (2.36 mm) sieve.

L. Sand: ASTM C 33; fine aggregate.

M. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

601: 3 - EXECUTION

601:3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

601:3.2 DEWATERING

A. Provide dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades, to the Engineer's approval.

B. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

C. Full detailed Method statement should be submitted prior to commencement; the method statement should be approved by the engineer.

D. ould be submitted prior to commencement; the method statement should be approved by the engineer.

E. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.

601:3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

601:3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.

1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, remove these materials then replace with satisfactory soil materials.
2. Remove rock to lines and grades indicated to permit installation of permanent construction without exceeding the following dimensions:

a. [ (600 mm)] outside of concrete forms other than at footings.
b. [ (300 mm)] outside of concrete forms at footings.
c. [ (150 mm)] outside of minimum required dimensions of concrete cast against grade.

d. Outside dimensions of concrete walls indicated to be cast against rock without forms or exterior waterproofing treatments.
e. [ (150 mm)] beneath bottom of concrete slabs-on-grade.
f. [ (150 mm)] beneath pipe in trenches, and the greater of [(600 mm)] wider than pipe or [ (1065 mm)] wide.

601:3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.
2. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Cut and protect roots.

601:3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

601:3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Excavate trenches to uniform widths to provide the following clearance on each side of pipe or conduit. Excavate trench walls vertically from trench bottom to (300 mm) higher than top of pipe or conduit unless otherwise indicated.

1. Clearance: (300 mm) each side of pipe or conduit.

C. Trench Bottoms: Excavate and shape trench bottoms to provide uniform bearing and support of pipes and conduit. Shape subgrade to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits. Remove projecting stones and sharp objects along trench subgrade.

1. For pipes and conduit less than (150 mm) in nominal diameter, hand-excavate trench bottoms and support pipe and conduit on an undisturbed subgrade.
2. For pipes and conduit (150 mm) or larger in nominal diameter, shape bottom of trench to support bottom 90 degrees of pipe or conduit circumference. Fill depressions with tamped sand backfill.

3. For flat-bottomed, multiple-duct conduit units, hand-excavate trench bottoms and support conduit on an undisturbed subgrade.
4. Excavate trenches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

D. Trench Bottoms: Excavate trenches (100 mm) deeper than bottom of pipe and conduit elevations to allow for bedding course. Hand-excavate deeper for bells of pipe.

1. Excavate trenches (150 mm) deeper than elevation required in rock or other unyielding bearing material to allow for bedding course.

E. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots .

## 601:3.8 EXCAVATION FOR ELEVATOR CYLINDER

A. Drill well hole plumb in elevator pit to accommodate installation of elevator-cylinder assembly. Coordinate with applicable requirements for diameter and tolerances.

B. Provide well casing as necessary to retain walls of well hole.

## 601:3.9 SUBGRADE INSPECTION AND CONSTRUCTION

A. Subgrade in Cut:

1. Where the subgrade is located in rock, the sub-grade, unless shown otherwise on the Drawings, shall be undercut to a depth of 200 mm by drilling or blasting as directed. No rock shall project more than 50 mm above the undercut surface elevation. The sub-grade layer shall then be constructed using approved sub-grade material, as specified for sub-grade in embankment.
2. Where the subgrade is on in-situ soil that is of a quality and CBR value at least equal to those specified for sub-grade, the 200 mm depth of such material immediately below top of sub-grade shall be scarified and all roots, sod, vegetable and other undesirable matter and stones larger than 75 mm in any dimension shall be removed. The material shall then be brought to a uniform moisture content within the specified range and compacted to 100% AASHTO T 180 (Method D) maximum density
3. Where the subgrade is on in-situ soil which is unsuitable for retention as the sub-grade layer, such material immediately below the top of subgrade layer shall be sub-excavated to a depth of 200 mm, hauled away and disposed off unless approved for use as embankment fill. The subgrade layer shall then be constructed using approved subgrade material, as specified for subgrade in embankment. If the material below subgrade layer does not satisfy the requirement of top 600 mm, it shall be excavated for further 200 mm and replaced by suitable material to satisfy the requirements of subgrade
4. The underlying natural material shall be scarified, leveled and rolled. The surface of the natural soil shall be approved by the Engineer before placement of suitable material.

B. Subgrade in Embankement:

1. The 200 mm minimum depth of embankment immediately below top of subgrade shall consist of selected, approved sub-grade material. The material shall be spread in one layer over the full width of the top of embankment, brought to a uniform moisture content within the specified range and compacted to 100% AASHTO T 180 (Method D) maximum density.

C. Surface Tolerances:

1. All finished elevations, lines and grades shall be in accordance with the details shown on the Drawings. Each cross section shall be checked at maximum intervals of 25 m, at each change in cross slope and elsewhere as directed.
2. The tolerances on elevations of finished sub-grade, top of embankment under the sub-grade layer and sub-excavated (undercut) surface shall be as follows:

| **Surface** | **Tolerance** |
|---|---|
| Finished Sub-grade: | |
| Soil | +10 or -30 mm |
| Rock (if approved) | +50 or -50 mm |
| Top of Embankment or Sub-excavated Surface: | +10 or -30mm |

3. When the finished subgrade surface is tested with a 4 m long straightedge placed parallel to, or at right angles to the centerline, the maximum depression of the surface from the testing by straight edge shall be 30 mm

D. Maintenance of Finished Subgrade:

1. The finished and approved sub-grade shall be continuously maintained in a smooth, well compacted and properly drained condition until the sub-base (or base) course is constructed. Reapproval of the subgrade will be required if the overlying course is not constructed within 14 days of sub-grade completion or if the subgrade layer is damaged by traffic or any other causes prior to the placement of the sub-base layer.

## 601:3.10 UNAUTHORIZED EXCAVATION

A. Fill unauthorized excavation under foundations or wall footings by extending bottom elevation of concrete foundation or footing to excavation bottom, without altering top elevation. Lean concrete fill, with 28-day compressive strength of (17.2 MPa), may be used when approved by the Engineer.

1. Fill unauthorized excavations under other construction, pipe, or conduit as directed by the Engineer.

## 601:3.11 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

601:3.12 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.

B. Place backfill on subgrades free of mud, frost, snow, or ice.

601:3.13 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.

B. Place and compact bedding course on trench bottoms and where indicated. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.

C. Trenches under Footings: Backfill trenches excavated under footings and within [ (450 mm)] of bottom of footings with satisfactory soil; fill with concrete to elevation of bottom of footings. Concrete is specified in concrete section

D. Trenches under Roadways: Provide [ (100-mm-)] thick, concrete-base slab support for piping or conduit less than [ (750 mm)] below surface of roadways. After installing and testing, completely encase piping or conduit in a minimum of [ (100 mm)] of concrete before backfilling or placing roadway subbase course. Concrete is specified in concrete section.

E. Backfill voids with satisfactory soil while removing shoring and bracing.

F. Place and compact initial backfill of subbase material and satisfactory soil, free of particles larger than [ (25 mm)] in any dimension, to a height of (300 mm) over the pipe or conduit.

1. Carefully compact initial backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing.

G. Place and compact final backfill of satisfactory soil to final subgrade elevation.

H. Install warning tape directly above utilities, (300 mm) below finished grade, except (150 mm) below subgrade under pavements and slabs.

601:3.14 SOIL FILL

A. Plow, scarify, bench, or break up sloped surfaces steeper than 1 vertical to 4 horizontal so fill material will bond with existing material.

B. Place and compact fill material in layers to required elevations as follows:

1. Under grass and planted areas, use satisfactory soil material.
2. Under walks and pavements, use satisfactory soil material.
3. Under steps and ramps, use engineered fill.

4. Under building slabs, use engineered fill.
5. Under footings and foundations, use engineered fill.

C. Place soil fill on subgrades free of mud, frost, snow, or ice.

601:3.15 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or fill soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

601:3.16 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Place backfill and fill soil materials in layers not more than 250 mm in loose depth for material compacted by heavy compaction equipment, and not more than 200 mm in loose depth for material compacted by hand-operated tampers.

B. Place backfill and fill soil materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.

C. Compact soil materials to not less than the following percentages of maximum dry unit weight according to ASTM D 1557:

1. Under structures, building slabs, steps, scarify and recompact top (300 mm) of existing subgrade and each layer of backfill or fill soil material at [100] percent.
2. Under walkways, scarify and recompact top (150 mm) below subgrade and compact each layer of backfill or fill soil material at [95] percent.
3. Under turf or unpaved areas, scarify and recompact top (150 mm) below subgrade and compact each layer of backfill or fill soil material at [85] percent.
4. For utility trenches, compact each layer of initial and final backfill soil material at [95] percent.
5. Under pavement structures, compact top 20cm of subgrade layer (CBR of 20%) at 100 percent of their maximum dry density and each layer of embankment soil material of the top 60 cm embankment fill at 95 percent of their maximum dry density determined according to AASHTO T-180 (Method D). The 4-Day soaked laboratory CBR of these layers should not be less than 15 percent. The material underneath the top 60 cm shall be compacted to the least 90.

601:3.17 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus [ (25 mm)].
2. Walks: Plus or minus [ (25 mm)]
3. Pavements: Plus or minus [ (13 mm)].

C. Grading inside Building Lines: Finish subgrade to a tolerance of [ (13 mm)] when tested with a (3-m) straightedge.

601:3.18 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud.

B. On prepared subgrade, place subbase course and base course under pavements and walks as follows:
1. Place base course material over subbase course under hot-mix asphalt pavement.
2. Shape subbase course and base course to required crown elevations and cross-slope grades.
3. Place subbase course and base course (150 mm to 200mm and as shown on the Drawings) in compacted thickness in a single layer.
4. Place subbase course and base course that exceeds (200 mm) in compacted thickness in layers of equal thickness, with no compacted layer more than (200 mm) thick or less than (150 mm) thick.
5. Compact subbase course and base course at optimum moisture content to required grades, lines, cross sections, and thickness to not less than 100 percent of maximum dry unit weight according to ASTM D 1557.

C. Pavement Shoulders: Place shoulders along edges of subbase course and base course to prevent lateral movement. Construct shoulders, at least (300 mm) wide, of satisfactory soil materials and compact simultaneously with each subbase and base layer to not less than 100 percent of maximum dry unit weight according to ASTM D 1557.

601:3.19 FIELD QUALITY CONTROL

A. Special Inspections: The Contractor will engage a qualified special inspector, approved by the Engineer, to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
2. Determine that fill material and maximum lift thickness comply with requirements.
3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.

B. Testing Agency: The Contractor will engage a qualified geotechnical engineering testing agency, approved by the Engineer, to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by the Engineer.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every [ (186 sq. m)] or less of paved area or building slab, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every [ (30 m)] or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every [ (46 m)] or less of trench length, but no fewer than two tests.

F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

601:3.20 PROTECTION

A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.

B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by the Engineer; reshape and recompact.

C. Where settling occurs before the Project’s Defects Liability Period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.

1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

601:3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Transport surplus satisfactory soil to designated storage areas on Employer's property. Stockpile or spread soil as directed by the Engineer.

1. Remove waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Employer's property.

# SECTION 602 - AGGREGATE SUBBASE COURSE

## 602: 1 - GENERAL

### 602: 1 - SUMMARY

A. This Section includes aggregate for subbase course composed of crushed aggregates constructed on the prepared underlying course in accordance with the Specification and shall conform to the lines, grades, dimensions and typical cross-section shown on the Drawings.

B. Related Sections include the following:

1. Division 60 Section 601 “Earth Moving” for subgrade preparation, grading, and base course
2. Division 60 Section 603 "Aggregate Base Course”
3. Division 60 Section 605 “Asphalt Paving”

### 602: 2 - DEFINITIONS

A. Aggregate Subbase Course: Subbase course composed of mineral aggregate uniformly blended and mixed with water.

B. Subgrade: Compacted soil layer immediately below the subbase course.

C. Subgrade Layer: 200 mm depth of soil material immediately below subgrade.

D. Test Section: 2000 m² of compacted aggregate subbase course, constructed for the purpose of verification of Contractor’s means, methods and equipment, and subject to approval by the Engineer, prior to commencement of the Work.

E. Lot of Compacted Material: 500 m² of compacted subbase course.

F. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

### 602: 3 - SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Samples: For the following:

1. 100-kg samples, sealed in airtight containers, of each proposed aggregate material.

C. Design Mixes: For subbase course mix, include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1. Provide compressive strength test results and moisture-density curves.

D. Qualifications Data: For firms and persons specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and Employers, and any other information required by the Engineer.

E. Material Test Reports: Form a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for backfill, fill, embankment and subgrade layer.
2. Laboratory compaction curve according to ASTM D 1557 for each on-site or borrow soil material proposed for backfill, fill, embankment and subgrade layer.
3. Laboratory compaction curve according to AASHTO T 180 (Method D) for each on-site or borrow soil material proposed for backfill, fill, embankment and subgrade layer
4. Cementitious materials and aggregates.

F. Material Certificates: Certificates signed by the manufacturers certifying that each material complies with requirements.

G. Field Records for the Following:

1. Test Section.
2. Verification of compliance of subgrade, in accordance with specified requirements, prior to placement of base course.
3. Laboratory reports; laboratory density test results for each lot.
4. Field reports; in-place density test results for each lot.

H. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by earthwork operations.

I. Minutes of preinstallation conference.

J. Daily Progress Reports: Include location of all construction joints.

602: 4 - QUALITY ASSURANCE

A. Codes and Standards: Comply with the local authority advisory circulars and standards, except where different requirements are specified or shown on the Drawings.

B. Installer Qualifications: Engage an experienced Installer who has completed aggregate subbase course similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

C. Manufacturer Qualifications: Engage a firm experienced in manufacturing similar to that indicated for this Project and with a record of successful in-service performance.

D. Testing Agency Qualifications: Demonstrate to the Engineer's satisfaction, based on the Engineer's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in access with standards without delaying the Work.

E. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.

602: 5 - PROJECT CONDITIONS

A. Provide a minimum 48 hour notice to the Engineer, and receive written notice to proceed, before interrupting any service, facility or utility operated or occupied by the Employer or others.

B. Protect subbase coarse from rain, wind and sun, indentation and physical damage.

C. Finished portions of the subbase course that are used by equipment in the construction of an adjoining section shall be protected to prevent marring or damaging the completed work.

D. Project Site Information: A sub-surface site investigation and test report has been prepared for Project and has been made available for information only. The report is not part of the Contract. The Contractor is entirely responsible for his own assessment, interpretation, use and conclusions drawn from the information, data, tests, analyses and opinions contained in any Site Investigation report discussed or related to the project conditions.

1. Make additional test borings and conduct other exploratory operations as necessary, at Contractor's own cost and expense.

E. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earthwork operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Employers and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

F. Notify utilities companies and authorities having jurisdiction for area where Project is located before commencing earthwork operations.

G. Existing Utilities: Do not interrupt utilities serving facilities on or adjacent to Project site unless permitted in writing by the Engineer and then only after arranging to provide temporary utility services according to requirements.

1. Notify the Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Engineer's written permission.

H. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

## 602: 2 - PRODUCTS

### 602:2.1 AGGREGATE

A. Aggregate: Shall be either natural gravel, crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel, or sand. Aggregate may be washed, if directed, to remove excessive quantities of clay, silty clay or salts.

B. Crushed Stone: Shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter, and shall contain not more than 8 percent flat, elongated, soft, or disintegrated pieces when tested to ASTM D4791.

C. Crushed Gravel: Shall consist of hard durable stones, rocks, and boulders crushed to specified sizes and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter.

D. The method used in production of crushed gravel shall be such that the finished product shall be as uniform as practicable. The crushing of the gravel shall result in a product, which shall have at least 90 percent by weight of particles with at least one fractured face. All stones, rocks, and boulders of inferior quality occurring in the pit shall be wasted.

E. Any material passing 4.75 mm (No. 4) sieve and produced in the crushing process shall be incorporated in the subbase material up to the gradation limits required for the subbase course aggregate.

F. The crushed aggregate shall meet the requirements of one of the gradation shown in Table 1 when tested in accordance with AASHTO T-11 and T-27.

TABLE 1: REQUIREMENTS FOR GRADATION OF AGGREGATE

| Sieve Designation (Square openings) | Percent by weight passing |
|---|---|
| 50 mm (2 in) | 100 |
| 25 mm (1 in) | 75 - 95 |
| 9.5 mm (3/8 in) | 40 - 75 |
| 4.75 mm (No.4) | 30 - 60 |
| 2.00 mm (No. 10) | 20 - 45 |
| 0.425 mm (No.40) | 15 - 30 |
| 0.075 mm (No.200) | 5 - 15 |

G. The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one half the fraction passing the No. 40 mesh sieve.

H. The percentage of wear shall not exceed 45 percent after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

I. The crushed aggregate subbase course material shall have a 4-day soaked CBR of not less than 30 when compacted at 100 percent of modified proctor, AASHTO T180 (Method D) and tested in accordance with AASHTO T 193.

J. When tested for soundness in accordance with AASHTO T 140, the material shall not show signs of disintegration and the loss by weight shall not exceed 12 percent in the case of the sodium sulphate test and 18 percent in the case of the magnesium sulphate test.

K. The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (LL) of not more than 25 and plasticity index (PI) of not more than 6 when tested in accordance with AASHTO T 89 and T 90.

L. If additional fine material is required to correct the aggregate gradation, or for adjusting the LL or PI of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material plant at the crushing plant or by an approved plant. Reworking of the material in situ to obtain the specified gradation will not be permitted. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or natural material.

M. The crushed aggregate subbase course material shall have chloride content of less than 0.1 percent and sulphate content of less than 0.2 percent when tested in accordance with BS 812.

N. The sand equivalent shall be 35% minimum when tested according to ASTM D2419.

O. The linear shrinkage of the crushed aggregate material shall not exceed 3% when tested according to BS 1377-2 standard.

P. The aggregate shall not contain more than 1% of clay lumps and friable particles when tested according to ASTM C142/ C142M.

## 602: 3 - EXECUTION

### 602:3.1 OPERATION AT SOURCES OF SUPPLY

A. All work involved in clearing and grubbing of quarries and pits, including the handling of unsuitable material, shall be performed at Contractor's own expense. The subbase material shall be obtained from approved sources. The material shall be handled in a manner that shall secure a uniform and satisfactory product.

### 602:3.2 EQUIPMENT

A. Equipment used to handle, place, spread, moisten, compact and finish the subbase course shall be on the site in first-class working condition, and approved by the Engineer before construction is permitted to start.

### 602:3.3 SURFACE PREPARATION

A. The aggregate subbase course shall be placed directly on completed subgrade, preparation and the subgrade surface shall be as specified in Section 601.

### 602:3.4 MIXING AND SPREADING

A. The subbase course material may be premixed with water, in a pugmill mixing plant or on site. The amount of water added, as determined, shall be such that the material will be uniform and within the specified moisture content range at the time of compaction.

B. The Engineer may allow other methods of mixing provided such methods(s) do not reduce the standard of work. Demonstrate, in the presence of the Engineer, the ability to attain the requirement given in the Specification.

C. Premixed material shall be placed on the subgrade in a uniform layer not less than 75 mm nor more than 200 mm of compacted thickness.

D. The subbase course material shall be placed to the required width using a self-propelled spreader or motor grader, and shall be delivered such that it is ready for compaction without further shaping.

E. The material shall not be handled in such a way as to cause segregation. If the spreader causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the spreader operation, the use of such spreader shall forthwith be discontinued and it shall be replaced by a spreader capable of spreading the material in a proper manner.

F. Segregated material shall be removed and replaced with well graded material. "Skin" patching will not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances will be permitted during the compaction process.

G. Hauling or placement of material will not be permitted when, in the judgement of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of subgrade or cause contamination of the subbase course material.

### 602:3.5 COMPACTION

A. Compaction: Plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If placing of succeeding layer of material is delayed to the extent that additional water is required to prevent ravelling or excessive drying, the application of such water shall be carried out in an approved manner and at Contractor's own expense.

B. Subbase course: material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the centre, with each succeeding pass uniformly overlapping the previous pass.

C. Rolling: Continue until the entire thickness of each subbase layer is thoroughly and uniformly compacted to 100 percent, as per AASHTO T 180 (Method D), maximum density.

1. Final rolling of the completed course shall be by means of an approved self-propelled roller.
2. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape.
3. When additional water is required, it shall be applied in an approved manner.

D. Areas Inaccessible to Normal Compaction: Compact by use of portable mechanical tampers until the required standard of compaction is achieved, or to the satisfaction of the Engineer.

E. Each layer shall be completely compacted and approved prior to delivery of materials for the following layer.

F. Prior to placing a following layer, the surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.

G. Edges and Edge Slopes of the Subbase Course: Bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

H. Material which has dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompacted using approved equipment and procedures. If unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerances, for the final layer only, scarify the material and reconstruct the subbase course on a re-approved sub-grade surface or to the satisfaction of the Engineer.

602:3.6 TOLERANCES AND MAINTENANCE OF COMPLETED SUBBASE

A. Compacted and Completed Subbase Course: Conform to the lines, grades and cross sections as shown on the Drawings.

B. Elevations of the Finished Subbase Course: Checked in the presence of the Engineer at intervals of 20m on straight lines and of 10m on curves, and at intermediate points as directed.

C. Tolerances (for final only): Elevations of finished surface shall not exceed + 10mm or - 15mm.

D. Finished Surface: When tested with a 4.0 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 12 mm.

E. Specified Tolerances: Areas which exceed shall be corrected by removing the defective sections of subbase course and reconstructing them or, by scarifying and adding new material and recompacting and finishing to the specified standard.

F. Completion and Acceptance of the Subbase Course: Maintained at Contractor's own expense as follows:

1. The surface shall be broomed, rolled and otherwise maintained, keeping it free from ravelling and other defects until such time as the following course is placed.
2. Water shall be applied at such times and in such quantities as directed.

602:3.7 FIELD QUALITY CONTROL

A. General

1. Testing Laboratory

a. Employ an independent testing agency to perform tests and to submit test reports
b. Be responsible for taking, identifying and delivering to the test laboratory all test samples called for in this specification. The testing laboratory shall be responsible for the testing. Collect all test results and deliver them to the Engineer in the format and details as specified.

B. Subbase Course Material: Test in accordance with Table 2 below after mixing with water at the mixing plant or in-situ compaction and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of the subbase course for full payment purposes.

C. Compaction: Test in accordance with ASTM D 1556 (Sand Cone Method) or ASTM D 2167 (Rubber balloon Method) or ASTM D 6938 (Nuclear Method). The Nuclear Method has to be first calibrated in comparison with Sand Cone Method for at least three sample tests. If there is a significant delay between the construction of any layer and the following layer, the Engineer may require the compaction of the lower layer to be re-verified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

D. Required Tests and Minimum Repetition for Subbase Course Material

TABLE 2:

| **(A) Source of Materials** | | **(B) Control on Site (The Road)** | |
|---|---|---|---|
| **Required Tests (A)** | **Repetition Required for all Test in (A)** | **Required Tests (B)** | **Repetition Required for all Tests in (B)** |
| 1. Gradation of material | As requested by the Engineer | 1. Proctor | As requested by the Engineer |
| 2. Plasticity Index and liquid limit | 1 sample in every 1000 m3 | 2. Gradation | As requested by the Engineer |
| 3. Abrasion | 1 sample in every 1000 m3 | 3. Plasticity Index and liquid limit | 1 sample in every 1000 m3 |
| 4. CBR | 1 sample in every 1000 m3 | 4. CBR | 1 sample in every 1000 m3 |
| 5. Sand equivalent | 1 sample in every 500 m3 | 5. Abrasion | 1 sample in every 1000 m3 |
| 6. Percentage of fractured Grains/Base course | As requested by the Engineer | 6. Sand Equivalent | 1 sample in every 500 m3 |
| 7. Chloride content (combined aggregate) | 1 sample in every 1000 m3 | 7. Clay lumps & friable Particles | 1 sample in every 1000 m3 |
| 8. Sulphate content (combined aggregate) | 1 sample in every 1000 m3 | 8. Field Density | 1 sample in every 500 m3 |
| 9. Flakiness and Elongation (combined aggregate) | 1 sample in every 1000 m3 | 9. Thickness | As requested by the Engineer |
| 10. Linear shrinkage | 1 sample in every 1000 m3 | - | - |

602:3.8 PROTECTION

1. Do not perform work when the Engineer determines that weather or other conditions are such that construction operations will damage the finished work.
2. Do not haul over aggregate subbase without approval. Repair damages resulting from occasional routing of equipment over the work.
3. Following the completion of the aggregate subbase course, all maintenance work necessary to keep the subbase course in a condition satisfactory for further work shall be performed.

# SECTION 603 - AGGREGATE BASE COURSE

## 603: 1 - GENERAL

### 603: 1 - SUMMARY

A. This Section includes aggregate for base course composed of crushed aggregates constructed on the prepared underlying course in accordance with the Specification and shall conform to the lines, grades, dimensions and typical cross-section shown on the Drawings.

B. Related Sections include the following:

1. Division 60 Section 601 “Earth Moving” for subgrade preparation, grading, and subbase course.
2. Division 60 Section 602 "Aggregate Subbase Course”.
3. Division 60 Section 605 “Asphalt Paving”.
4. Division 60 Section 608 “Concrete Paving”.

### 603: 2 - 1.3 DEFINITIONS

A. Aggregate Base Course: Base course composed of mineral aggregate uniformly blended and mixed with water.

B. Subgrade: Compacted soil layer immediately below the subbase or base course.

C. Subgrade Layer: 200 mm depth of soil material immediately below subgrade.

D. Test Section: 2000 m² of compacted aggregate base course, constructed for the purpose of verification of Contractor’s means, methods and equipment, and subject to approval by the Engineer, prior to commencement of the Work.

E. Lot of Compacted Material: 500 m² of compacted base course.

F. Utilities include on-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

### 603: 3 - SUBMITTALS

A. Product Data: For each type of manufactured material and product indicated.

B. Samples: For the following:

1. 100 kg samples, sealed in airtight containers, of each proposed aggregate material.

C. Design Mixes: For base course mix, include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

1. Provide compressive strength test results and moisture-density curves.

D. Qualifications Data: For firms and persons specified in “Quality Assurance” Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects/engineers and Employers, and any other information required by the Engineer.

E. Material Test Reports: Form a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

1. Classification according to ASTM D 2487 of each on-site or borrow soil material proposed for backfill, fill, embankment and subgrade layer.
2. Laboratory compaction curve according to ASTM D 1557 for each on-site or borrow soil material proposed for backfill, fill, embankment and subgrade layer.
3. Laboratory compaction curve according to AASHTO T 180 (Method D) for each on-site or borrow soil material proposed for backfill, fill, embankment and subgrade layer
4. Cementitious materials and aggregates.

F. Material Certificates: Certificates signed by the manufacturers certifying that each material complies with requirements.

G. Field Records for the following:

1. Test Section.
2. Verification of compliance of subgrade or subbase, in accordance with specified requirements, prior to placement of base course.
3. Laboratory reports; laboratory density test results for each lot.
4. Field reports; in-place density test results for each lot.

H. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by earthwork operations.

I. Minutes of preinstallation conference.

J. Daily progress reports, to include location of all construction joints.

603: 4 - QUALITY ASSURANCE

A. Codes and Standards: Comply with the local authority advisory circulars and standards, except where different requirements are specified or shown on the Drawings.

B. Installer Qualifications: Engage an experienced Installer who has completed aggregate base course similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

C. Manufacturer Qualifications: Engage a firm experienced in manufacturing similar to that indicated for this Project and with a record of successful in-service performance.

D. Testing Agency Qualifications: Demonstrate to the Engineer's satisfaction, based on the Engineer's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in access with standards without delaying the Work.

E. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt and concrete paving work.

F. Pre-installation Conference: Conduct conference at the Project site .

603: 5 - PROJECT CONDITIONS

A. Provide a minimum 48 hour notice to the Engineer, and receive written notice to proceed, before interrupting any service, facility or utility operated or occupied by the Employer or others.

B. Protect base coarse from rain, wind and sun, indentation and physical damage.

C. Finished portions of the base course that are used by equipment in the construction of an adjoining section shall be protected to prevent marring or damaging the completed work.

D. Project Site Information: A sub-surface site investigation and test report has been prepared for Project and has been made available for information only. The report is not part of the Contract. The Contractor is entirely responsible for his own assessment, interpretation, use and conclusions drawn from the information, data, tests, analyses and opinions contained in any Site Investigation report discussed or related to the project conditions.

1. Make additional test borings and conduct other exploratory operations as necessary, at Contractor's own cost and expense.

E. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earthwork operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Employers and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by authorities having jurisdiction.

F. Notify utilities companies and authorities having jurisdiction for area where Project is located before commencing earthwork operations.

G. Existing Utilities: Do not interrupt utilities serving facilities on or adjacent to Project site unless permitted in writing by the Engineer and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Engineer not less than two days in advance of proposed utility interruptions.
2. Do not proceed with utility interruptions without the Engineer's written permission.

H. Demolish and completely remove from site existing underground utilities indicated to be removed. Coordinate with utility companies to shut off services if lines are active.

## 603: 2 - PRODUCTS

### 603:2.1 AGGREGATE

A. Aggregate: Shall be either crushed stone or crushed gravel. The fine aggregate shall consist of screenings obtained from crushed stone, gravel, or sand. Aggregate may be washed, if directed, to remove excessive quantities of clay, silty clay or salts.

B. Crushed Stone: Shall consist of hard, durable particles or fragments of stone, free from dirt or other objectionable matter, and shall contain not more than 8 percent of flat, elongated, soft, or disintegrated pieces when tested according to ADTM D4791.

C. Crushed Gravel: Shall consist of hard durable stones, rocks, and boulders crushed to specified sizes and shall be free from excess flat, elongated, soft or disintegrated pieces, dirt, or other objectionable matter.

D. The method used in production of crushed gravel shall be such that the finished product shall be as uniform as practicable. The crushing of the gravel shall result in a product, which shall have at least 90 percent by weight of particles with at least one fractured face. All stones, rocks, and boulders of inferior quality occurring in the pit shall be wasted.

E. Any material passing 4.75 mm (No. 4) sieve and produced in the crushing process shall be incorporated in the base material up to the gradation limits required for the base course aggregate.

F. The crushed aggregate shall meet the requirements of one of the gradation shown in Table 1 when tested in accordance with AASHTO T-11 and T-27

TABLE 1: REQUIREMENTS FOR GRADATION OF AGGREGATE

| Sieve Designation (Square openings) | Percent by weight passing Class A |
|---|---|
| | |
| 50 mm (2 in) | 100 |
| 37 mm (1 ½ in) | 95 - 100 |
| 25 mm (1 in) | 70 - 95 |
| 19 mm (¾ in) | 55 - 85 |
| 9.5 mm (3/8 in) | 40 - 70 |
| 4.75 mm (No.4) | 30 - 60 |
| 0.60 mm (No.30) | 12 - 30 |
| 0.075 mm (No.200) | 5 - 10 |

G. The amount of the fraction of material passing the No. 200 mesh sieve shall not exceed one half the fraction passing the No. 40 mesh sieve.

H. The percentage of wear shall not exceed 35 percent after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

I. The crushed aggregate base course material shall have a 4-day soaked CBR of not less than 80 when compacted at 100 percent of Modified Proctor AASHTO T180 (Method D) and tested in accordance with AASHTO T 193.

J. When tested for soundness in accordance with AASHTO T 140, the material shall not show signs of disintegration and the loss by weight shall not exceed 12 percent in the case of the sodium sulphate test and 18 percent in the case of the magnesium sulphate test.

K. The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (LL) of not more than 25 and plasticity index (PI) of not more than 4 when tested in accordance with AASHTO T 89 and T 90.

L. If additional fine material is required to correct the aggregate gradation, or for adjusting the LL or PI of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material plant at the crushing plant or by an approved plant. Reworking of the material in-situ to obtain the specified gradation will not be permitted. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or natural material.

M. The crushed aggregate base course material shall have chloride content of less than 0.1 percent and sulphate content of less than 0.20 percent when tested in accordance with BS 812.

N. The sand equivalent shall be 50% minimum when tested according to ASTM D2419.

O. The linear shrinkage of the crushed aggregate material shall not exceed 3% when tested according to BS 1377-2 standard.

P. The aggregate shall not contain more than 1% of clay lumps and friable particle when tested according to ASTM C142/ C142M.

## 603: 3 - EXECUTION

### 603:3.1 OPERATION AT SOURCES OF SUPPLY

A. All work involved in clearing and grubbing of quarries and pits, including the handling of unsuitable material, shall be performed at Contractor's own expense. The base material shall be obtained from approved sources. The material shall be handled in a manner that shall secure a uniform and satisfactory product.

### 603:3.2 EQUIPMENT

A. All equipment used to handle, place, spread, moisten, compact and finish the base course shall be on the site in first-class working condition, and approved by Engineer before construction is permitted to start.

### 603:3.3 SURFACE PREPARATION

A. The aggregate base course shall be placed directly on the completed subgrade or subbase. Preparation of the subgrade surface shall be as specified in Section 601.

### 603:3.4 MIXING AND SPREADING

A. The base course material may be premixed with water, in a pugmill mixing plant. The amount of water added, as determined, shall be such that the material will be uniform and within the specified moisture content range at the time of compaction.

B. The Engineer may allow other methods of mixing provided such methods(s) do not reduce the standard of work. Demonstrate, in the presence of the Engineer, the ability to attain the requirement given in the Specification.

C. Premixed material shall be placed on the subgrade in a uniform layer not less than 75 mm nor more than 200 mm of compacted thickness.

D. The base course material shall be placed to the required width using a self-propelled spreader or motor grader, and shall be delivered such that it is ready for compaction without further shaping.

E. The material shall not be handled in such a way as to cause segregation. If the spreader causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the spreader operation, the use of such spreader shall forthwith be discontinued and it shall be replaced by a spreader capable of spreading the material in a proper manner.

F. Segregated material shall be removed and replaced with well graded material. "Skin" patching will not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances will be permitted during the compaction process.

G. Hauling or placement of material will not be permitted when, in the judgement of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of subgrade or cause contamination of the base course material.

### 603:3.5 COMPACTION

A. Compaction: Plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces. If placing of succeeding layer of material is delayed to the extent that additional water is required to prevent ravelling or excessive drying, the application of such water shall be carried out in an approved manner and at Contractor's own expense.

B. Base course material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the centre, with each succeeding pass uniformly overlapping the previous pass.

C. Rolling: Continue until the entire thickness of each base layer is thoroughly and uniformly compacted to 100 percent, as per AASHTO T 180 (Method D), maximum density.

1. Final rolling of the completed course shall be by means of an approved self-propelled roller.
2. Rolling shall be accompanied by sufficient blading, to ensure a smooth surface, free from ruts or ridges and having the proper shape.
3. When additional water is required, it shall be applied in an approved manner.

D. Areas Inaccessible to Normal Compaction: Compact by use of portable mechanical tampers until the required standard of compaction is achieved, or to the satisfaction of the Engineer.

E. Each layer shall be completely compacted and approved prior to delivery of materials for the following layer.

F. Prior to placing a following layer, the surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.

G. Edges and Edge Slopes of the Base Course: Bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

H. Material which has dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompacted using approved equipment and procedures. If unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerances, for the final layer only, scarify the material and reconstruct the base course on a re-approved subbase surface or to the satisfaction of the Engineer.

## 603:3.6 TOLERANCES AND MAINTENANCE OF COMPLETED BASE

A. Compacted and Completed Base Course: Conform to the lines, grades and cross sections as shown on the Drawings.

B. Elevations of the Finished Base Course: Checked in the presence of the Engineer at intervals of 20m on straight lines and of 10m on curves, and at intermediate points as directed.

C. Tolerances (for final only): Elevations of finished surface shall not exceed + 10mm or - 15mm.

D. Finished Surface: When tested with a 4.0 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 12 mm.

E. Specified Tolerances: Areas which exceed shall be corrected by removing the defective sections of base course and reconstructing them or, by scarifying and adding new material and recompacting and finishing to the specified standard.

F. Completion and Acceptance of the Base Course: Maintained at Contractor's own expense as follows:

1. The surface shall be broomed, rolled and otherwise maintained, keeping it free from ravelling and other defects until such time as the following course is placed.
2. Water shall be applied at such times and in such quantities as directed.

G. The aggregate base needs to be mechanically swept and cleaned with compressed air before the application of prime coat.

The base shall be sealed with prime coat before the it is dried out. If the surface has dried out then light watering and recompaction may be done before applying prime coat. If full depth is dry, the whole base shall be removed and replaced.

603:3.7 FIELD QUALITY CONTROL

A. General:
1. Testing Laboratory:

a. Employ an independent testing agency to perform tests and to submit test reports
b. Be responsible for taking, identifying and delivering to the test laboratory all test samples called for in this specification. The testing laboratory shall be responsible for the testing. Collect all test results and deliver them to the Engineer in the format and details as specified

B. Base Course Material: Test in accordance with Table 2 below after mixing with water at the mixing plant or in-situ compaction and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of the base course for full payment purposes.

C. Compaction: Test in accordance with ASTM D 1556 (Sand Cone Method) or ASTM D 2167 (Rubber balloon Method) or ASTM D 6938 (Nuclear Method). The Nuclear Method has to be first calibrated in comparison with Sand Cone Method for at least three sample tests. If there is a significant delay between the construction of any layer and the following layer, the Engineer may require the compaction of the lower layer to be re-verified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

D. Required Tests and Minimum Repetition for Base Course Material

TABLE 2:

| **(A) Source of Materials** | | **(B) Control on Site (The Road)** | |
|---|---|---|---|
| **Required Tests (A)** | **Repetition Required for all Test in (A)** | **Required Tests (B)** | **Repetition Required for all Tests in (B)** |
| 1. Gradation of Material | As requested by the Engineer | 1. Proctor | As requested by the Engineer |
| 2. Plasticity Index and liquid limit | 1 sample in every 1000 m3 | 2. Gradation | As requested by the Engineer |
| 3. Abrasion | 1 sample in every 1000 m3 | 3. Plasticity Index and liquid limit | 1 sample in every 1000 m3 |
| 4. CBR | 1 sample in every 1000 m3 | 4. CBR | 1 sample in every 1000 m3 |
| 5. Sand equivalent | 1 sample in every 500 m3 | 5. Abrasion | 1 sample in every 1000 m3 |
| 6. Percentage of fractured Grains/Base course | As requested by the Engineer | 6. Sand Equivalent | 1 sample in every 500 m3 |

| (A) Source of Materials | | (B) Control on Site (The Road) | |
|---|---|---|---|
| **Required Tests (A)** | **Repetition Required for all Test in (A)** | **Required Tests (B)** | **Repetition Required for all Tests in (B)** |
| 7. Chloride content (combined aggregate) | 1 sample in every 1000 m3 | 7. Clay lumps & friable Particles | 1 sample in every 1000 m3 |
| 8. Sulphate content (combined aggregate) | 1 sample in every 1000 m3 | 8. Field Density | 1 sample in every 500 m3 |
| 9. Flakiness and Elongation (combined aggregate) | 1 sample in every 1000 m3 | 9. Thickness | As requested by the Engineer |
| 10. Linear shrinkage | 1 sample in every 1000 m3 | - | - |

603:3.8 PROTECTION

1. Do not perform work when the Engineer determines that weather or other conditions are such that construction operations will damage the finished work.
2. Following the completion of the crushed aggregate base course, all maintenance work necessary to keep the base course in a condition satisfactory for further work shall be performed.

# SECTION 604 - EXCAVATION SUPPORT AND PROTECTION

## 604: 1 - GENERAL

### 604:1.1 SUMMARY

A. Section includes temporary excavation support and protection systems.

### 604:1.2 PERFORMANCE REQUIREMENTS

B. Design**,** furnish, install, monitor, and maintain excavation support and protection system capable of supporting excavation sidewalls and of resisting soil and hydrostatic pressure and superimposed and construction loads.

1. Delegated Design: Design excavation support and protection system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Prevent surface water from entering excavations by grading, dikes, or other means.
3. Install excavation support and protection systems without damaging existing buildings, structures, and site improvements adjacent to excavation.
4. Monitor vibrations, settlements, and movements.
5. Removal of excavation support and protection systems

### 604:1.3 SUBMITTALS

C. Shop Drawings: Excavation support and protection system design and calculations shall be acceptable to authorities having jurisdiction, and should include:
1. Shop drawings signed and sealed by the qualified professional engineer responsible for their preparation.
2. Calculations for excavation support and protection, including but not limited to the following:
   a. Soil parameters used and their substantiation
   b. Codes, standards and methods followed
   c. Principle underlying selection of system
3. Layout, mark and number: type, dimensions, location and details of each support and protection system and its components.

D. Method Statement: Provide a detailed narrative describing means, methods and techniques to be implemented for construction of excavation support and protection systems. The Method Statement shall include, but not limited to, the following:
1. Details of equipment and monitoring instrumentation, quality control, testing and reporting procedures, work program, and any other information required by the Engineer.
2. Contingency plan outlining procedures to be adopted in the event that problems arise during construction work

E. Delegated-Design Submittal: For excavation support and protection system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

F. Qualification Data: For qualified land surveyor.

G. Material Certificates: Signed by manufacturers certifying that material and product components comply with specified requirements

H. Field Records: Survey data

I. Other Informational Submittals:

1. Photographs or Videotape: Show existing conditions of adjacent construction and site improvements that might be misconstrued as damage caused by the absence of, the installation of, or the performance of excavation support and protection systems. Submit before Work begins.
2. Record Drawings: Identifying and locating capped utilities and other subsurface structural, electrical, or mechanical conditions.

    a. Note locations and capping depth of wells and well points.

604:1.4 QUALITY ASSURANCE

J. Installer Qualifications: Engage an experienced installer specialized in installing excavation support and protection system similar to those required for this Project and with a record of successful performance.

K. Professional Engineer Qualifications: Engage a qualified professional engineer to prepare or supervise the preparation of data for the excavation support and protection system including drawings and comprehensive engineering analysis that shows the system's compliance with specified requirements

L. Preinstallation Conference: Conduct conference at Project site prior to commencing the installation of the excavation support and protection system.

1. Review methods and procedures related to excavation support and protection system including, but not limited to, the following:

    a. Geotechnical report.
    b. Existing utilities and subsurface conditions.
    c. Proposed excavations.
    d. Proposed equipment.
    e. Monitoring of excavation support and protection system.
    f. Working area location and stability.
    g. Coordination with waterproofing.
    h. Abandonment or removal of excavation support and protection system.
    i. Safety requirements.

604:1.5 PROJECT CONDITIONS

M. Notify utilities companies and authorities having jurisdiction before commencing excavation support and protection system operations.

N. Interruption of Existing Utilities: Do not interrupt any utility serving facilities on the Project site or on adjoining properties unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Engineer no fewer than two days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without the Engineer's written permission.

O. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. The Employer will not be responsible for interpretations or conclusions drawn from the data.

1. Make additional test borings and conduct other exploratory operations necessary for excavation support and protection.
2. The geotechnical report is included elsewhere in the Project Manual.

P. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements; establish exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During installation of excavation support and protection systems, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations and positions for comparison with original elevations and positions. Promptly notify the Engineer if changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.

2. Before starting excavation support work, survey conditions of adjoining properties, including foundation level and type. Take photographs to record their existing conditions

## 604: 2 - PRODUCTS

### 604:2.1 MATERIALS

Q. General: Provide materials that are either new or in serviceable condition.

R. Structural Steel: ASTM A 36/A 36M, ASTM A 690/A 690M, or ASTM A 992/A 992M.

S. Steel Sheet Piling: ASTM A 328/A 328M, ASTM A 572/A 572M, or ASTM A 690/A 690M; with continuous interlocks.

1. Corners: Site-fabricated mechanical interlock or Roll-formed corner shape with continuous interlock.

T. Wood Lagging: Lumber, mixed hardwood, nominal rough thickness of size and strength required for application [ (75 mm )] [ (100 mm)] .

U. Shotcrete: Comply with specifications for shotcrete materials and mixes, reinforcement, and shotcrete application.

V. Cast-in-Place Concrete: ACI 301, of compressive strength required for application.

W. Reinforcing Bars: ASTM A 615/A 615M, Grade 420, deformed.

X. Tiebacks: Steel bars, ASTM A 722/A 722M.

Y. Tiebacks: Steel strand, ASTM A 416/A 416M.

## 604: 3 - EXECUTION

### 604:3.1 PREPARATION

Z. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards that could develop during excavation support and protection system operations.

1. Shore, support, and protect utilities, sidewalks, pavements and structures encountered.

AA. Install and construct excavation support and protection systems to ensure minimum interference with adjoining roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, sidewalks, pavements, or other adjacent occupied or used facilities without permission from the Engineer and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by the Engineer or authorities having jurisdiction.

BB. Locate excavation support and protection systems clear of permanent construction so that forming and finishing of concrete surfaces are not impeded.

CC. Monitor excavation support and protection systems daily during excavation progress and for as long as excavation remains open. Promptly correct bulges, breakage, or other evidence of movement to ensure that excavation support and protection systems remain stable.

DD. Promptly repair damages to adjacent facilities caused by installing excavation support and protection systems.

### 604:3.2 SOLDIER PILES AND LAGGING

EE. Install steel soldier piles before starting excavation. Extend soldier piles below excavation grade level to depths adequate to prevent lateral movement. Space soldier piles at regular intervals not to exceed allowable flexural strength of wood lagging. Accurately align exposed faces of flanges to vary not more than 50 mm from a horizontal line and not more than 1:120 out of vertical alignment] .

FF. Install wood lagging within flanges of soldier piles as excavation proceeds. Trim excavation as required to install lagging. Fill voids behind lagging with soil, and compact.

GG. Install wales horizontally at locations indicated on Drawings and secure to soldier piles.

### 604:3.3 SHEET PILING

HH. Before starting excavation, install one-piece sheet piling lengths and tightly interlock to form a continuous barrier. Accurately place the piling, using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer. Limit vertical offset of adjacent sheet piling to (1500 mm). Accurately align exposed faces of sheet piling to vary not more than 50 mm from a horizontal line and not more than 1:120 out of vertical alignment] . Cut tops of sheet piling to uniform elevation at top of excavation.

604:3.4 TIEBACKS

II. Prior to drilling for tiebacks, investigate to ensure that installation of tiebacks will not interfere with or cause damage to underground utilities or structures adjacent to the site.

JJ. Drilling: Drill to required length for each tieback. Maintain accurate work records and produce a log for each drill hole in a form acceptable to the Engineer, including the following data:
1. Project name and number,
2. Location and identity of drill hole
3. Diameter of drill hole
4. Date and time of starting and completing drilling,
5. Overall length of drill hole,
6. Description of soil materials recovered,
7. Description and location of obstructions encountered,
8. Ground-water conditions,
9. Remarks, including conditions encountered.

KK. Tiebacks: Drill, install, grout, and tension tiebacks. Test load-carrying capacity of each tieback and replace and retest deficient tiebacks at no extra cost.

1. Test loading shall be observed by a qualified professional engineer responsible for design of excavation support and protection system.
2. Maintain tiebacks in place until permanent construction is able to withstand lateral soil and hydrostatic pressures.

604:3.5 BRACING

LL. Bracing: Locate bracing to clear columns, floor framing construction, and other permanent work. If necessary to move brace, install new bracing before removing original brace.

1. Do not place bracing where it will be cast into or included in permanent concrete work unless otherwise approved by the Engineer.
2. Install internal bracing, if required, to prevent spreading or distortion of braced frames.
3. Maintain bracing until structural elements are supported by other bracing or until permanent construction is able to withstand lateral earth and hydrostatic pressures.

604:3.6 REMOVAL AND REPAIRS

MM. Remove excavation support and protection systems when construction has progressed sufficiently to support excavation and bear soil and hydrostatic pressures. Remove in stages to avoid disturbing underlying soils or damaging structures, pavements, facilities, and utilities.

1. Remove excavation support and protection systems to a minimum depth of 1200 mm below overlaying construction and abandon remainder.
2. Fill voids immediately with approved backfill compacted to density specified in Section601 "Earth Moving."
3. Repair or replace, as approved by the Engineer, adjacent work damaged or displaced by removing excavation support and protection systems.

NN. Leave excavation support and protection systems permanently in place.

# SECTION 605 - ASPHALT PAVING

## 605: 1 - GENERAL

### 1.1 SUMMARY

A. This Section includes the following:

1. Hot-mix asphalt paving.
2. Cold milling of existing hot-mix asphalt pavement.
3. Bituminous concrete surface course.
4. Bituminous concrete base course.
5. Bituminous prime and tack coats.
6. Hot-mix asphalt patching.
7. Hot-mix asphalt overlay.
8. Pavement-marking paint.
9. Traffic-calming devices.

B. Related Sections include the following:

1. Section 601 "Earth Moving" for excavation, fill and subgrade construction.
2. Section 602 "Aggregate Subbase Course" for subbase courses.
3. Section 603 "Aggregate Base Course" for base courses.
4. Section 608 " Concrete Paving".
5. Section 609 " Concrete Paving Joint Sealants".
6. Section 610 " Pavement Demolishing"

### 1.2 SYSTEM DESCRIPTION

A. Provide bituminous concrete pavement according to the materials, workmanship, and other applicable requirements of the Standard Specifications.

1. Standard Specification: As indicated.

### 1.3 SUBMITTALS

A. Product Data: For each product specified. Include technical data and tested physical and performance properties.

B. Job-Mix Designs: For each job mix proposed for the Works.

C. Shop Drawings: Indicate pavement markings, lane separations, and defined parking spaces. Indicate dedicated handicapped spaces with international graphics symbol.

D. Qualification Data: For firms and people specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of engineers and employers, and other information specified or required by Engineer.

E. Material Test Reports: Indicate and interpret test results for compliance of materials with requirements indicated.

F. Material Certificates: Certificates signed by manufacturers certifying that each material complies with requirements.

## 1.4 QUALITY ASSURANCE

A. Installer Qualifications: Engage an experienced installer who has completed hot-mix asphalt paving similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

B. Manufacturer Qualifications: Engage a firm experienced in manufacturing hot-mix asphalt similar to that indicated for this Project and with a record of successful in-service performance.

C. Testing Agency Qualifications: Demonstrate to Engineer's satisfaction, based on Engineer's evaluation of criteria, that the independent testing agency has the experience and capability to satisfactorily conduct the testing indicated in accordance with Standards, without delaying the Works.

D. Regulatory Requirements: Conform to applicable standards of authorities having jurisdiction for asphalt paving work.

E. Asphalt Paving Publications: Comply with AI's "The Asphalt Handbook", except where other requirements are stipulated.

F. Preinstallation Conference: Conduct conference at Project site. Review methods and procedures related to asphalt paving including, but not limited to, the following:

1. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
2. Review condition of substrate and preparatory work performed by other trades.
3. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
4. Review and finalize construction schedule for paving and related work. Verify availability of materials, paving Installer's personnel, and equipment required to execute the Work without delays.
5. Review inspection and testing requirements, governing regulations, and proposed installation procedures.
6. Review forecasted weather conditions and procedures for coping with unfavorable conditions.

## 1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver pavement-marking materials to Project site in original packages with seals unbroken and bearing manufacturer's labels containing brand name and type of material, date of manufacture, and directions for storage.

B. Store pavement-marking materials in a clean, dry, protected location and within the temperature range required by manufacturer. Protect stored materials from direct sunlight.

## 1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not apply asphalt materials if substrate is wet or excessively damp or during wet weather the following conditions are not met:

1. Prime and Tack Coats: Minimum surface temperature of 15 deg C.
2. Bituminous Base Course: Minimum surface temperature of 15 deg C and rising at time of placement.

B. Bituminous Wearing Course: Minimum surface temperature of 15 deg C at time of placement Pavement-Marking Paint: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of 4 deg C for oil-based materials and/or 12 deg C for water-based materials, and not exceeding (35 deg C).

## 605: 2 - PRODUCTS

### 2.1 AGGREGATE

A. General: Use materials and gradations that have performed satisfactorily in previous installations.

B. General: Crushed stone, screenings and mineral filler, with or without sand meeting the specified gradation.

C. Aggregates for use in the bituminous wearing layers shall consist of 100% crushed stone from a hard-high quality aggregate material, .

D. Aggregates shall consist of not more than 8 percent of flat elongated pieces according to U.S. Army, Corps of Engineers CRD C119 or ASTM D4791. A flat particle is one having a ratio of width to thickness greater than five. An elongated particle is one having a ratio of length to width greater than five.

E. Passing a stripping test (95% minimum) according to ASTM D3625/D3625M “Standard Practice for Effect of Water on Bituminous-Coated Aggregate Using Boiling Water”.

F. Aggregates shall comply with the following:

| | | |
|---|---|---|
| 1. | Liquid Limit (ASTM D 4318) | 25 maximum |
| 2. | Plasticity Index (ASTM D 4318) | Non-plastic |
| 3. | Loss by Abrasion Test (ASTM C 131) | 30 percent maximum for bituminous base course and 25 percent maximum for bituminous wearing course |
| 4. | Soundness Test, Loss of Weight using Sodium Sulfate (5 cycle) (ASTM C 88) | 10 per cent maximum |
| 5. | Soundness Test, Loss of Weight using Magnesium Sulfate (5 cycle) (ASTM C 88) | 10 percent maximum |
| 6. | Fine Aggregate Water Absorption (ASTM C 128) | 2.0 percent maximum |
| 7. | Coarse Aggregate Water Absorption (ASTM C 127) | 2.0 percent maximum |
| 8. | Chloride Content (BS 812) | 0.1 percent maximum |
| 9. | Sulphate content (BS 812) | 0.2 per cent maximum |
| 10. | Sand Equivalent (ASTM D2419) | 50 minimum |

G. Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained as 4.75mm (No. 4) sieve, at least 100% by weight shall have 1 (one) fractured faces and minimum 85% by weight having at least two fractured faces.

H. Fine aggregates shall be clean and free of organic matter, clay, clay lumps or deleterious material.

I. Addition of sand, with the approval of the Engineer, shall be limited to natural sand in a quantity not to exceed 15 percent of the combined weight of coarse and fine aggregate and mineral filler. The use of wadi, beach or dune sand is not permitted in asphalt concrete mixes.

J. The fine aggregate material for the bituminous wearing and base layers shall have a minimum angularity of 45% when tested in accordance with AASHTO T304-Method A standard.

K. Mineral Filler: Rock or slag dust, hydrated lime or hydrated cement or other inert material complying with ASTM D 242.

L. Combined aggregates meeting the following requirements when tested according to ASTM C 136:

| **Sieve Size (mm)** | **Minimum % Passing** | **Maximum % Passing** | **Minimum % Passing** | **Maximum % Passing** | **Minimum % Passing** | **Maximum % Passing** |
|---|---|---|---|---|---|---|
| | **12.5mm NMAS** | | **19 mm NMAS** | | **25 mm NMAS** | |
| 37.5 | 100 | 100 | 100 | 100 | 100 | 100 |
| 25.0 | 100 | 100 | 100 | 100 | 90 | 98 |
| 19.0 | 100 | 100 | 86 | 100 | 68 | 90 |
| 12.5 | 79 | 99 | 69 | 87 | 57 | 78 |
| 9.5 | 68 | 88 | 58 | 78 | 49 | 69 |
| 4.75 | 48 | 68 | 40 | 60 | 34 | 56 |
| 2.36 | 33 | 53 | 25 | 45 | 22 | 42 |
| 1.18 | 20 | 40 | - | - | 13 | 29 |
| 0.85 | - | - | 15 | 30 | - | - |
| 0.600 | 14 | 30 | - | - | 8 | 21 |
| 0.425 | - | - | 10 | 22 | - | - |
| 0.300 | 9 | 21 | - | - | 6 | 14 |
| 0.18 | - | - | 6 | 15 | - | - |
| 0.150 | 6 | 16 | - | - | 4 | 10 |
| 0.075 | 3 | 6 | 2 | 8 | 3 | 6 |

M. Coarse Aggregate: Sound; angular crushed stone or crushed gravel; complying with D692/D692M.

N. Fine Aggregate: Sharp-edged natural sand or sand prepared from stone or gravel, or combinations thereof; complying with ASTM D1073.

## 2.2 ASPHALT MATERIALS

A. Asphalt Cement: ASTM D 946/D 946M for penetration-graded material; Grade 60-70 (mixing temperature 145 deg C - 165 deg C).

B. Prime Coat: ASTM D 2027/D2027M; medium-curing cutback asphalt; MC-70.

C. Prime Coat: ASTM D 977, emulsified asphalt or ASTM D 2397/D2397, cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

D. Tack Coat: ASTM D 977, emulsified asphalt or ASTM D 2397/D2397, cationic emulsified asphalt, slow setting, factory diluted in water, of suitable grade and consistency for application.

E. Tack Coat: ASTM D 2028/D2028M; rapid curing cutback asphalt; RC-70.

F. Water: Potable.

G. Asphalt material shall be obtained from approved sources, approved by the Engineer on site.

2.3 Paving Geotextile/Geogrid Membrane: AASHTO M 288, nonwoven polypropylene; resistant to chemical attack, rot, and mildew; and specifically designed for paving applications

2.4 MIXES

A. Hot-Mix Asphalt: Provide dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction and designed according to procedures in AI's "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types, or in accordance with the Marshall method for Asphalt Institute Manual MS-2.

1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
2. Provide mixes complying with the composition, grading, and tolerance requirements of ASTM D 3515 for the following nominal, maximum aggregate sizes:

   a. Base Course: 25 mm.
   b. Wearing Course: 19 mm.

B. Combine the mineral aggregates and asphalt to conform to the following composition limits by weight:

1. Total Mineral Aggregates:

| | |
|---|---|
| Bituminous Base Course | 95.5 to 96.5 percent |
| Bituminous Wearing Course | 95.5 to 96.5 percent |

2. Asphaltic Binder:

| | |
|---|---|
| Bituminous Base Course | 3.5 to 4.5 percent |
| Bituminous Wearing Course | 3.5 to 4.5 percent |

C. Asphaltic mixtures with maximum aggregate size of 25 mm shall be tested according to ASTM D6926 (75 blows each face) and shall satisfy the below requirements. For asphaltic mixtures with maximum aggregate size greater than 25mm, testing shall be carried out according to ASTM D5581 (112 blows each face) but in this case the Marshall Mix specified properties shall be reviewed to account for the larger size aggregates to the satisfaction of the Engineer.

| Test Required | Base Course | Wearing Course |
|---|---|---|
| Marshall Stability (N) | 10,000 | 12,000 |
| Flow (mm) | 2-3.5 | 2-4 |
| Stiffness, minimum (N/mm) | 4500 | 4900 |
| Voids in total mix, %VIM | 4.0 to 7.0 percent | 4.0 to 7.0 percent |
| Voids in mineral aggregate based on maximum aggregate size, VMA (%) | Min 14 (19mm NMAS)<br>Min 13 (25mm NMAS) | Min 14 (19mm NMAS)<br>Min 15 (12.5mm NMAS) |
| Voids Filled with Bitumen, VFB (%) | 50-70 | 60-70 |
| Loss of Marshall Stability by submerging specimens in water at 60°C for 24 h. compared to stability measured after submersion in water at 60°C for 30 minutes. | Max. 25% | Max. 25% |
| % Air Voids at Refusal* | 2 min. | 2 min. |
| Filler/Bitumen ratio | 0.8-1.5 | 0.8-1.5 |

* Prior to final approval, the proposed job mix, but with a bituminous content at the upper percentage limits shall be compacted to refusal, (400 to 600 blows) and the resulting voids in the mix shall not be less than 2%.

D. Variation from the approved job-mix, based on results of 4 tests, shall not exceed the following:

1. Aggregates passing No. 4 (4.75 mm) and larger ± 4 percent
2. Aggregates passing No. 8 (2.36 mm), No. 16 (1.18 mm), No. 30 (0.6 mm), and No. 50 (0.3 mm) ± 3 percent
3. Aggregates passing No. 100 (0.15 mm) and No. 200 (0.075 mm) ± 1 percent
4. Asphalt content ± 0.2 percent
5. Temperature of mixing and placing ± 10 deg C
6. Air voids in total mix ± 1 percent

E. When tested for resistance to water damage in accordance with AASHTO T 283 “Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage”, the bituminous wearing course mixture shall have a retained tensile strength greater than or at least equal to 80%. In case the anti-stripping agents are not successful in providing the specified Tensile Strength Ratio, then the Contractor shall consider alternative means, such as the use of hydrated lime to achieve this purpose.

## 605: 3 - EXECUTION

### 3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to support paving and imposed loads.

B. Proof-roll the aggregate base course using heavy, pneumatic-tired rollers to locate areas that are unstable or that require further compaction.

C. Inspect surfaces on which asphalt materials are to be placed for conformance to the required compaction, grades, and sections.

D. Notify Engineer in writing of any unsatisfactory conditions. Do not begin paving installation until these conditions have been satisfactorily corrected.

### 3.2 COLD MILLING

A. Clean existing paving surface of loose and deleterious material immediately before cold milling. Remove existing asphalt pavement, including hot-mix asphalt and, as necessary, unbound-aggregate base course, by cold milling to grades and cross sections indicated.

### 3.3 PATCHING AND REPAIRS

A. All saw-cutting and breaking of defective pavements of any type, cleaning, patching, sealing or carrying out pavement repair works shall be coordinated with the Engineer through the submission of detailed method statement for every area that needs repair. The method statement should show the extent of patching or repair works, the steps that shall be followed and the materials that shall be used for each type of repair, with due consideration to the applicability of the proposed method and materials to each specific repair case. The execution shall not start before receiving the written approval of the Engineer. The requirements set in Clauses B, C and D below, are for guidance only and shall be coordinated with the approved method statement and with the Engineer on Site.

B. Patching: Saw cut perimeter of patch and excavate defective pavement section to sound base. Recompact new subgrade. Excavate rectangular or trapezoidal patches, extending 300 mm into adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically.

1. Tack coat faces of excavation and allow to cure before paving.
2. Fill excavation with dense-graded, hot-mix asphalt base mix and, while still hot, compact flush with adjacent surface.
3. Partially fill excavation with dense-graded, hot-mix asphalt base mix and compact while still hot. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.

C. Leveling Course: Install and compact leveling course consisting of dense-graded, hot-mix asphalt wearing course to level sags and fill depressions deeper than 25 mm in existing pavements.

1. Install leveling wedges in compacted lifts not exceeding 75 mm thick.

D. Crack and Joint Filling: Remove existing filler material from cracks or joints to a depth of 6 mm. Refill with asphalt joint-filling material to restore watertight condition. Remove excess filler that has accumulated near cracks or joints.

1. Tack Coat: Apply according to Article 3.6.

## 3.4 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

1. Sweep loose granular particles from surface of unbound-aggregate base course. Do not dislodge or disturb aggregate embedded in compacted surface of base course.
2. Remove loose materials from existing asphalt pavement and clean surface using approved mechanical sweepers, blowers, and hand brooms. Remove loose broken, or shattered asphaltic material along the edges of existing surfaces. Shape, blade, and broom the exposed subgrade and a sufficient width of shoulder to provide a uniform firm subgrade for the new surface course.
3. Remove loose materials from existing PCC pavement and clean surface using approved mechanical sweepers, blowers, and hand brooms. Shape, blade, and broom the exposed subgrade and a sufficient width of shoulder to provide a uniform firm subgrade for the new surface course.

B. Herbicide Treatment: Apply herbicide according to manufacturer's recommended rates and written application instructions. Apply to dry, prepared subgrade or surface of compacted-aggregate base before applying paving materials.

1. Mix herbicide with prime coat when formulated by manufacturer for that purpose.

C. Prime Coat: Apply according to Article 3.6.

D. Control of Traffic: Do not permit unnecessary traffic on the surface after it has been approved to receive asphaltic material.

## 3.5 TRIAL SECTIONS

A. At the start of plant operation, place a trial section for each Job Mix Formula used. Construct a trial section 100 m long and two paver-widths wide (operating simultaneously), with a longitudinal cold joint. The trial section shall be of the same depth as the course which it represents. The underlying grade or pavement structure upon which the trial section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the trial section shall be the same equipment to be used on the remainder of the course represented by the trial section. The trial section shall be placed at locations approved by the Engineer on Site.

B. One random sample shall be taken at the plant, triplicate specimens compacted, and tested for stability, flow, and laboratory air voids. A portion of the same sample shall be tested for theoretical maximum density, aggregate gradation and asphalt content. Four randomly selected cores shall be taken from the finished pavement mat, and four from the longitudinal joint, and tested for density. Random sampling shall be in accordance with procedures contained in ASTM D3665. The test results shall conform to all specified requirements for work to continue. If all test results meet the specified requirements, the trial section shall remain as part of the project pavement. If test results exceed the specified tolerances, the test section shall be removed and replaced at no cost to the project and another test section shall be constructed.

C. If the initial trial section should prove to be unacceptable, the necessary adjustments to the Job Mix Formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second trial section shall then be placed. Additional trial sections, as required, shall be constructed and evaluated for conformance to the specifications. Full production shall not begin until an acceptable section has been constructed and accepted.

## 3.6 PRIME AND TACK COATS

A. General: Prepare a test section of an approved length for determining the rate of application for each type of material. Subsequent test sections may be required and previously established rate or rates of application may be altered when necessary.

B. Prime Coat: Apply uniformly over surface of compacted-aggregate base to a line 200 mm outside edge of pavement line, at a rate of 0.75 to 1.50 L/sq. m. The specific rate of application of the prime coat shall be established based on successful site trials. Apply enough material to penetrate and seal, but not flood, surface. Allow prime coat to cure for 48 hours minimum.

1. Apply liquid asphalt at temperatures within the range of 50 to 70 deg C. Reject materials heated to temperatures above 108 deg C until the material can be resampled and retested.
2. If prime coat is not entirely absorbed within 24 hours after application, spread sand over surface to blot excess asphalt. Use just enough sand to prevent pickup under traffic. Remove loose sand by sweeping before pavement is placed and after volatiles have evaporated.
3. Protect primed substrate from damage until ready to receive paving.

C. Tack Coat: Apply uniformly to existing surfaces of previously constructed asphalt or Portland cement concrete paving and to surfaces abutting or projecting into new, hot-mix asphalt pavement. Apply at a uniform rate of 0.30 to 0.60 L/sq. m of surface. The specific rate of application of the tack coat shall be established based on successful site trials.

1. Apply liquid asphalt at temperatures within the range of 50 to 70 deg C. Reject materials heated to temperatures above 108 deg C until the material can be resampled and retested.
2. Allow tack coat to cure undisturbed before paving.
3. Avoid smearing or staining adjoining surfaces, appurtenances, and surroundings. Remove spillages and clean affected surfaces.

D. Application:

1. Apply by approved pressure distributors. Spray nozzles and spray bar shall be adjusted and frequently checked to ensure uniform distribution. Stop spraying upon clogging or interference of any nozzles, and take corrective measures before resuming.
2. Hand sprays will be approved only for priming small patches or areas that cannot be primed by normal operation of the distributor.
3. Application at the junction of spreads shall not be in excess of the specified amount. Squeeze excess from the surface and correct skipped and deficient areas by means of approved hand sprayers.

E. Blotting: When approved, after the material has been applied for 48 hours and has not dried sufficiently, apply a light application of sand as blotter material. Apply blotting material sparingly and only on areas that have not dried.

## 3.7 PAVING GEOTEXTILE/GEOGRID INSTALLATION

A. Apply Tack Coat or Asphalt Binder or Asphalt Cement uniformly to existing pavement surfaces ata rate of (0.8 to 1.2 L/sq. m).

B. As shown on the Drawings, place paving geotextile/geogrid promptly according to manufacturer's written instructions. Broom or roll geotextile smooth and free of wrinkles and folds. Overlap longitudinal joints (100 mm) and transverse joints (150 mm).

1. Protect paving geotextile/Geogrid from traffic and other damage and place hot-mix asphalt paving overlay the same day.

## 3.8 ASPHALTIC CONCRETE BATCHING AND MIXING

A. Preparation of Asphalt Cement: Heat asphalt cement within a temperature range of 135 deg C to 163 deg C at the time of mixing. All material heated to more than 204 deg C in storage tanks shall be rejected.

B. Preparation of Mineral Aggregate:

1. Heat and dry aggregates to a temperature after screening of not more than 163 deg C. Reject and remove aggregates from the bins, if they contain sufficient moisture to cause foaming in the mixture, or if their temperature is in excess of 163 deg C.

2. Immediately after heating, screen aggregates into at least 3 sizes and convey into separate bins ready for batching and mixing. When separating into three bins is impractical, the number of separations may be reduced to two with approval. Screen and produce gradations of heated and dried aggregates which are reasonably uniform and result in the production of a mixture as specified.

C. Preparation of Asphaltic Mixture:

1. Introduce aggregates and asphalt cement into the mixture in proportionate amount according to the job-mix formula. The temperature of the asphalt, except for temporary fluctuations, shall be not lower than 32 deg C below the temperature of the aggregate at the time the materials enter the mixer or pug mill.
2. Use the shortest mixing time that will produce a satisfactory mixture based on the procedure for determining the percentage of coated particles described in ASTM D2489/D2489M. The mixing times shall be set to achieve 90 percent of coated particles for base mixtures and 95 percent of coated particles for wearing mixtures.
3. Dry mixing time, if required for the batch plants, shall not exceed 10 seconds. Wet mixing time shall not exceed 50 seconds. Timing shall begin at the start of asphalt introduction into the pug mill at batch plants.
4. The length of mixing time for continuous plants shall be determined by the following formula or other approved methods:

$$\text{Mixing time in seconds} = \frac{\text{Pugmill dead capacity in kilos}}{\text{Pugmill output in kilos/second}}$$

D. Preparation of Hot-Mix Asphalt Placement:

1. Apply a prime coat or tack coat to surface on which asphaltic concrete is to be placed, unless otherwise approved.
2. Maintain line and grade control by means of taut reference string lines or other approved methods. If the existing surface is determined to be acceptable, it may be used for control, and the use of the string line waived. If directed, establish and maintain centerline points.

## 3.9 HOT-MIX ASPHALT PLACING

A. Spread and finish asphaltic concrete true-to-line and grade by means of an automatically controlled paver except that the use of the automatically controlled paver may be waived and a manually controlled paver or hand methods may be used on irregular or other sections when approved.

B. Place the mixture in consecutive, adjacent strips with a minimum width of 3 m except where edge lanes require strips of lesser width. Unless otherwise directed, begin placing along the centerline of crowned sections or on the high side or areas with a one-way slope.

C. Operate the paver at a speed which will give the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mixture to the paver so as to provide a uniform rate of placement without intermittent operation of the paver. Regulate the speed of the paver to eliminate pulling and tearing of the bituminous mat.

D. Deliver asphaltic concrete to the paver at a temperature between 135 and 163 deg C. Do not use mixtures delivered to the paver at temperatures outside this range.

E. The maximum thickness for layers may be increased when such increase is determined not to be detrimental to placement and rolling conditions.

F. Make surface test to check conformity with the specified crown and grade immediately after initial compression. Correct all variations by the removal or addition of materials and by continuous rolling. The finished surface shall not vary by more than the specified tolerances. After the completion of final rolling, retest the smoothness of the course. Immediately correct all humps and depressions exceeding the specified tolerances, as approved. Replace and recompact the pavement where holes are made for test purposes.

## 3.10 JOINTS

A. Make joints so as to ensure thorough and continuous bond. Construct transverse construction joints free of depressions, with same texture and smoothness as other sections of hot-mix asphalt course.

B. Clean contact surfaces and apply tack coat in previously laid material by cutting the material back vertically for its full depth so as to expose a fresh surface. Transverse joints in one layer shall be offset by at least 600 mm from transverse joints in the previous layer. Transverse joints in adjacent lanes shall be offset a minimum of 3 m.

C. Offset longitudinal joints in successive layers not less than 300 mm.

D. Before placing the fresh mixture against a cut joint or against old pavement, spray or paint the contact surface with a thin uniform coat of liquid asphalt. Where a finishing machine is used, make the longitudinal joint by overlapping the screed on the previously laid material for a minimum width of 25 mm and depositing a sufficient amount of material so that the joint formed will be smooth and tight.

## 3.11 COMPACTION

A. After spreading and strike-off, compact the asphaltic concrete to the density specified in Sub-Clause 3.15.C.3. Complete rolling before appearance of cracks.

B. Begin initial or breakdown rolling as soon as the asphaltic concrete will bear the roller without undue displacement. Roll longitudinally, beginning at the low side of the work and proceeding toward the high side, or centerline.

1. Overlay successive strips by at least one half the drum width. Alternate trips of the roller shall be of different lengths.

C. Prevent adhesion of mixture by moisten the roller drums with water; an excess of water will not be permitted.

D. Follow initial or breakdown rolling by rolling with a pneumatic-tire roller. Perform finish rolling with tandem roller. Select number and size of roller required to obtain the specified density.

E. Operate rollers continuously so that all areas of the pavement will receive substantially equal compaction. Placing will be ordered to stop at any time that proper rolling is not being performed.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials. Remove paving course over area affected and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.

## 3.12 ASPHALT CURBS

A. Not Applicable.

## 3.13 CONTACT SURFACES

A. Paint contact surfaces of concrete structures with a thin uniform coating of approved asphaltic material. Place asphaltic concrete uniformly high near contact surfaces so that after compaction it shall be 6 mm above the edge of such structures.

## 3.14 QUALITY CONTROL AND TESTING

A. General:

1. Testing Laboratory:

a. Employ an independent testing agency to perform the specified quality control tests, test mixes and to submit official test reports.

b. Be responsible for taking, identifying and delivering to the test laboratory all test samples called for in this Specification. The testing laboratory shall be responsible for the testing. Collect all test results and deliver them to the Engineer in the format and detail as specified.

2. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is (6 mm).

## 3.15 SURFACE TREATMENTS

A. Not Applicable.

## 3.16 FIELD QUALITY CONTROL

A. Sampling: The job shall be divided into lots of 2000 metric tons. Each lot will further be subdivided into four equal sublots. One random sample shall be taken from each sublot and tested. For aggregate gradation, asphalt content and in-place density tests, samples shall be taken from in-place asphaltic concrete paving. For Marshall test, samples shall be taken from trucks.

B. Testing: Tests shall be performed in accordance with the following:

1. Marshall Stability and Flow of Bituminous Mixtures: ASTM D6927.
2. Bulk Specific Gravity of Compacted Bituminous Mixture: ASTM D2726/D2726M.

C. Acceptance:

1. The gradation will be acceptable when variation from the approved job mix for the average of four samples is within the limits of tolerances specified.
2. The asphalt content will be acceptable when variation from the approved job mix for the average of four samples is within the limits of tolerances specified.
3. The compaction density for all bituminous courses shall be equal to or greater than 98% of the average Marshall bulk specific gravity for each day's production unless otherwise directed by the Engineer.
4. Surfaces: Refer to Sub-Clause 3.18.B of this specification section.
5. Elevations: Variations from gradeline, elevations and cross sections are not to exceed 10 mm above or 6 mm below the elevations shown. Straightedge will be used for testing of transverse irregularities.

D. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances (Sub-Clause 3.18.B).

E. In-Place Density: Samples of uncompacted paving mixtures and compacted pavement will be secured by testing agency according to ASTM D979/D979M.

1. Reference laboratory density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D6926, and compacted according to job-mix specifications.
2. Reference maximum theoretical density will be determined by averaging results from 4 samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D2041/D2041M, , and compacted according to job-mix specifications.
3. In-place density of compacted pavement will be determined by testing core samples according to ASTM D1188 or ASTM D 2726/D2726M.

4. One core sample will be taken for every 800 sq. m or less of installed pavement, but in no case will fewer than 3 cores be taken. Cores shall be reinstated by placing "Repair Cold Asphalt" in the core holes and compacting it with tamping rod to the satisfaction of the Engineer.
5. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D2950/D2950M and correlated with ASTM D1188 or ASTM D2726/D2726M.

F. Determination of Thickness of Courses.

1. Compensate for minor deficiencies in the thickness of any bituminous course in the pavement structure by increasing the thickness of the subsequent bituminous course. After completion of the final (wearing) course any deficiencies in the thickness of any course which have not been compensated for by increasing the thickness of a subsequent course, will be considered deficiencies in the final (wearing) course.
2. Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.
3. Thickness of bituminous courses shall be determined by average caliper measurement of cores, rounded upwards to the nearest mm.
4. Paved sections to be measured separately shall consist of each 300 lin.m section in each paved strip. The last section in each paved strip shall be 300 m plus the fractional part of 300 m remaining. Other areas such as intersections, entrances, crossovers, ramps, etc. shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.
5. One core shall be taken from each section at approved locations and in the presence of the Engineer. When the measurement of the core from any paved section is not deficient by more than 5 mm from the specified thickness, the core will be deemed to be of the specified thickness as shown on the Drawings.
6. When the measurement of the core from any paved section is deficient by more than 5 mm but not more than 20 mm, 2 additional cores spaced at not less than 100 m shall be taken and used together with the first core to determine the average thickness of such section.
7. When the measurement of the core from any paved section is less than the specified thickness by more than 20 mm, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 20 mm. Exploratory cores for deficient thickness will not be used in average thickness determinations.
8. Any deficiencies in the total thickness of bituminous courses shall be subject to a proportional reduction in the volume of final (wearing) course measured for payment. Alternatively, construct all at your own expense, a surface course overlay, if practicable in the judgement of the Engineer. Any such overlay shall be a minimum of 40 mm compacted thickness and to the specified standard of the course it is overlaying.
9. If the deficiency in total asphalt layers thickness is from 0 - 3mm, full payment will be made, on condition that deficiencies are not found in more than 10% of the total project. Deficiencies between 3mm and 10mm, 80% of the full payment for the bituminous courses will be made.

3.17 TESTING FREQUENCY

| (A) Source of Materials | | (B) Control on Site | |
|---|---|---|---|
| Required Tests (A) | Repetition Required for all Test in (A) | Required Tests (B) | Repetition Required for all Tests in (B) |
| Gradation of Material | As requested by Engineer | 1. Coring | 1 sample in every 800 $m^2$ |
| Quality Testing on the material | 1 sample in every 1000 $m^3$ | 2. In-place density | 1 sample in every 800 $m^2$ |
| | | 3. Asphalt content | As requested in the Specification |
| | | 4. Bulk specific gravity | As requested in the Specification |
| | | 5. Volumetric tests | As requested in the Specification |
| | | 6. Pavement density tests | As requested in the Specification |
| | | 7. Smoothness | As requested in the Specification |
| | | 8. Plastic Flow | As requested in the Specification |
| | | 9. Thickness | As requested in the Specification |

3.18 INSTALLATION TOLERANCES

A. Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 10 mm.
2. Wearing Course: Plus 6 mm, no minus.

B. Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 3-m straightedge applied transversely or longitudinally to paved areas:

1. Base Course: 6 mm.
2. Wearing Course: 3 mm.
3. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 6 mm.

# SECTION 608 - CONCRETE PAVING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 1 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes exterior cement concrete pavement for Container Stacking Yards.

B. Related Sections include the following:
1. Section 601 “Earth Moving” for subgrade preparation and aggregate subbase and base courses.
2. Section 603 "Aggregate Base Course" for base courses.
3. Section 609 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.

### 1.3 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of cementitious additives such as fly ash, ground granulated blast-furnace slag, and silica fume.

B. Base Course: Bituminous base course or aggregate base course placed beneath the concrete pavement.

### 1.4 SUBMITTALS:

A. Product data for proprietary materials and items, including reinforcement (wherever applicable) and forming accessories, admixtures, joint systems, curing compounds, dry-shake finish materials, and others if requested by Engineer.

B. Shop Drawings: Include layout, sections, and joint details.

C. Qualification Data: For firms and persons specified in the "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of engineers and employers, and other information specified.

D. Design Mixes: For each concrete pavement mix. Include alternate mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

E. Samples: 4.5-kg sample of exposed aggregate.

F. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:

G. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:

1. Cement, Cementitious materials and aggregates.
2. Steel reinforcement and reinforcement accessories.
3. Admixtures.
4. Curing compounds.
5. Applied finish materials.
6. Bonding agent or adhesive.
7. Joint fillers.

H. Photographs or videotape, sufficiently detailed, of existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by installation or failure of special excavation support and protection systems.

I. Minutes of preinstallation conference.

J. Material Test Report: Indicate and interpret test results for compliance of materials with requirements indicated.

K. Field Reports:

1. Submit three copies of the following reports directly to Engineer from the testing services:
    a. Test reports and product data verifying the suitability of aggregate (to include source of the aggregate), cement, admixtures, joint filler and sealants, dowels, tie bars, mesh reinforcement, curing material and other materials as requested by Engineer.
    b. Test report on preliminary design of concrete mix: At least 15 days prior to the start of paving operations and after approval of all material to be used in the concrete, submit a mix design showing the proportions and actual flexural strength obtained from the concrete. [The mix design shall include a complete list of materials including type; brand; source and amount of cement and admixtures; and copies of test reports].
2. At least 30 days before the commencement of paving operation, submit a detailed method statement, for approval by Engineer.
3. Verification of suitability of base course, in accordance with requirements, prior to placement of pavement.
4. Pour Records (three copies): Record in an approved form, details of every pour of concrete placed in the pavement including date, location of pour, ambient temperature and temperature of concrete at placement, moisture content of aggregate, details of mix, results of tests and details of cores.
5. Weekly Records (three copies): Report covering work carried out the preceding week, to include location of all joints.
6. Monthly Records (three copies): Provide monthly histograms of all 28-day cube or cylinder strengths and accumulative standard deviations and other information, which the Engineer may require concerning placement of the pavement.

## 1.5 QUALITY ASSURANCE:

A. Codes and Standards: Comply with the Provisions of the following standards, except where more stringent requirements are specified or shown on Drawings:

1. ACI 211.1, 301, 305 and 318.
2. CRSI "Manual of Standard Practice".

B. Material and Installed Work: May require testing and re-testing at anytime during progress of work. Tests, including re-testing of rejected material for installed work, shall be done at own expense.

C. Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.

D. Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products complying with ASTM C94/C94M requirements for production facilities and equipment.

E. Testing Agency Qualifications: An independent testing agency, acceptable to Engineer, qualified according to ASTM C1077 and ASTM E 329 to conduct the testing indicated.

F. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source.

G. Equipment and Tools: As necessary for handling materials and performing all parts of the work shall be approved by Engineer as to design, capacity, and mechanical condition. The equipment shall be at the job site before the start of construction operations for examination and approval.

H. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests, design concrete mixes, and perform field quantity control testing.

I. Mockups: Cast mockups of full-size sections of concrete pavement to demonstrate typical joints, surface finish, texture, color, and standard of workmanship.

1. Build mockups in the location and of the size indicated or, if not indicated, as directed by Engineer.
2. Notify Engineer seven days in advance of dates and times when mockups will be constructed.
3. Obtain Engineer's approval of mockups before starting construction.
4. Maintain approved mockups during construction in an undisturbed condition as a standard for judging the completed pavement.
5. Demolish and remove approved mockups from the site when directed by Engineer.
6. Approved mockups may become part of the completed Works if undisturbed at time of Taking Over.

J. Preinstallation Conference: Conduct conference at Project site to comply with the project requirements..

1. At least 35 days prior to submitting design mixes, review concrete pavement mix design and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with concrete pavement to attend, including the following, as applicable:

a. Engineer.
b. Contractor's superintendent.
c. Independent testing agency responsible for concrete design mixes.
d. Ready-mix concrete producer.
e. Concrete subcontractor.

## 1.6 PROJECT CONDITIONS

A. Protect Finished Pavement: Protect from spatter during concrete placement of adjacent sections.

B. Protect Fresh Concrete: Cover completed fresh concrete with temporary cover as required to protect newly cast pavement from direct sun in hot weather - above 35 deg C - and maintain cover until curing starts.

C. Protect Immature Concrete: Protect from physical shock, movement, thermal shock and cold water.

D. Protect Surfaces: Protect from rain, wind, sun, indentation and physical damage.

E. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

## PART 2 - PRODUCTS

### 2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.

1. Use flexible or curved forms for curves of a radius 30 m or less.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.

### 2.2 STEEL REINFORCEMENT: Refer to Section E21 “Reinforcement for Insitu Concrete”.

A. Joint Dowel Bars: Plain-steel bars, ASTM A615/A 615M, Grade 60. Cut bars true to length with ends square and free of burrs.

B. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Use wire bar type supports complying to CRSI's "Manual of Standard Practice".

1. For exposed-to-view concrete surfaces, where legs of wire bar supports contract forms, use CRSI, Class 1 plastic protected, or CRSI Class 2 stainless steel, bar supports.

C. Epoxy Repair Coating: Liquid two-part epoxy repair coating, compatible with epoxy coating on reinforcement.

D. Tie Bars: ASTM A 615M, Grade 60, deformed.

E. Hook Bolts: ASTM F 568M, Property Class 4.6, internally and externally threaded. Design hook-bolt joint assembly to hold coupling against concrete slab form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

F. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Use wire bar type supports complying to CRSI's "Manual of Standard Practice".

1. For exposed-to-view concrete surfaces, where legs of wire bar supports contract forms, use CRSI, Class 1 plastic protected, or CRSI Class 2 stainless steel, bar supports.

### 2.3 CONCRETE MATERIALS

A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project, unless otherwise accepted by Engineer.

B. Portland Cement: ASTM C 150/C 150 M, Type V or NL 53 Type CEM I 42.5 PRMS.

C. Aggregate: ASTM C 33/C 33M or BS EN 12620. Aggregates shall consist of natural sand alone or in combination with crushed stone. The aggregate shall be composed of sound, tough, durable particles and shall meet the requirements for deleterious substances given in ASTM C33/C33M or BS EN 12620. The aggregate in any size group shall not contain more than 8 percent by weight of flat or elongated pieces when tested in accordance with ASTM D 4791. A flat or elongated particle is one having a ratio between the maximum and the minimum dimensions of a circumscribing rectangular prism exceeding 5 to 1. Uniformly graded, from a single source, with coarse aggregate as follows:

1. Maximum Aggregate Size: 25 mm nominal or 19 mm nominal.
2. Do not use fine or coarse aggregates containing substances that cause spalling.

D. Exposed Aggregate: Selected, hard, and durable; washed; free of material that reacts with cementitious material or causes staining.

E. Aggregate Gradation:

1. Fine Aggregate: Conform to the requirements of ASTM C33/C33M. The % fines (material passing #200 sieve) shall not exceed 3% for natural sand and 5% for combined fine aggregate mixture. The sand equivalent of the fine aggregate material shall be 75 minimum when tested according to ASTM D2419 and the specific gravity and % absorption shall be 2.6 minimum and 2% maximum, respectively, when tested according to ASTM C128.

F. Coarse Aggregate: Conform to the requirements of ASTM C33/C33M, depending on the maximum aggregate size of the material used. The percentage of wear shall be no more than 30% when tested in accordance with ASTM C131. The specific gravity and % absorption shall be 2.6 minimum and 2% maximum, respectively, when tested according to ASTM C127.

G. Water: Water used in mixing or curing shall be as clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product as possible. Water will be tested in accordance with the requirements of AASHTOT26, ASTM C94/C94M. The chloride content shall not exceed 500ppm.

## 2.4 ADMIXTURES

A. General: Admixtures certified by manufacturer to contain not more than 0.1 percent water-soluble chloride ions by mass of cement and to be compatible with other admixtures.

B. General: The use of any material added to the concrete mix shall be approved by Engineer. Submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, Engineer may require the submittal of complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests will be made of samples taken by Engineer from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

C. Air Entraining Admixtures: Air-entraining admixtures shall meet the requirements of ASTM C260/C260M and shall be added to the mix in the amount necessary to produce the specified air content. The air-entrainment agent and the water reducer admixture shall be compatible.

D. Chemical Admixtures: Water reducing, set-retarding, and set-accelerating admixtures shall meet the requirements of ASTM C494/C494M.

1. Water-Reducing Admixture: ASTM C494/C494M, Type A.
2. High-Range, Water-Reducing Admixture: ASTM C494/C494M, Type F.
3. Water-Reducing and Accelerating Admixture: ASTM C494/C494M, Type E.
4. Water-Reducing and Retarding Admixture: ASTM C494/C494M, Type D.

## 2.5 CURING MATERIALS

A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately. 305 g/sq. m dry.

B. Moisture-Retaining Cover: ASTM C171, polyethylene film or white burlap-polyethylene sheet.

C. Water: Potable.

D. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works include, to the approval of the Engineer.

E. Clear Solvent-Borne Liquid-Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B.

F. Clear Waterborne Membrane-Forming Curing Compound: ASTM C309, Type 1, Class B.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works include, to the approval of the Engineer.

G. White Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works include, to the approval of the Engineer.

## 2.6 RELATED MATERIALS

A. Premolded Joint Filler: Conform to the requirements of ASTM D1751 and shall be punched to admit the dowels where called for on the plans.

1. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber.
2. Expansion- and Isolation-Joint-Filler Strips: ASTM D1752, cork or self-expanding cork.
3. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber, or ASTM D1752, cork or self-expanding cork.

B. Joint Filler: Furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to Engineer.

C. Joint Sealer: Meet the requirements of Section 609 “Concrete Paving Joint Sealants” of the specification and shall be of the type(s) specified on drawings.

D. Coloring Agent: ASTM C979/C979M, synthetic mineral-oxide pigments or colored water-reducing admixtures; color stable, nonfading, and resistant to lime and other alkalis.

1. Color: As indicated by manufacturer's designation.
2. Color: Match Engineer’s sample.
3. Color: As selected by Engineer from manufacturer's full range.

E. Bonding Agent: ASTM C 1059/C1059M, Type II, non-redispersible, acrylic emulsion or styrene butadiene.

F. Epoxy Bonding Adhesive: ASTM C881/C881M, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class and grade to suit requirements, and as follows:

1. Type II, non-load bearing, for bonding freshly mixed concrete to hardened concrete.
2. Types I and II, non-load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.
3. Types IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

G. Chemical Surface Retarder: Water-soluble, liquid set retarder with color dye, for horizontal concrete surface application, capable of temporarily delaying final hardening of concrete to a depth of 3 to 6 mm.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works, to the approval of the Engineer.

H. Pigmented Mineral Dry-Shake Hardener: Factory-packaged, dry combination of portland cement, graded quartz aggregate, color pigments, and plasticizing admixture. Use color pigments that are finely ground, nonfading mineral oxides interground with cement.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works, to the approval of the Engineer.

I. Colored Dry-Shake Hardener: Factory-packaged dry combination of Portland cement, graded quartz aggregate, coloring pigments, and plasticizing admixture. Use coloring pigments that are finely ground, nonfading mineral oxides interground with cement.
1. Color Hardener.
2. Color: As indicated by manufacturer's designation.
3. Color: Match Engineer’s samples.
4. Color: As selected by Engineer from manufacturer's full range.

## 2.7 WHEEL STOPS

A. Wheel Stops: Precast, air-entrained concrete, 17.2-MPa minimum compressive strength, as per the dimensions shown on the Drawings. Provide chamfered corners and drainage slots on underside and holes for anchoring to substrate.

1. Dowels: Galvanized steel, 20 mm in diameter, 250 mm minimum length.

B. Wheel Stops: Solid, integrally colored, 96 percent recycled HDPE, or commingled postconsumer and postindustrial recycled rubber or plastic]; UV stabilized; as per the dimensions shown on the Drawings. Provide chamfered corners and drainage slots on underside and holes for anchoring to substrate.

1. Color: As indicated on the Drawings.
2. Dowels: Galvanized steel, 20 mm) in diameter, 250 mm minimum length.
3. Adhesive: As recommended by wheel stop manufacturer for application to concrete pavement.

## 2.8 CONCRETE MIXES

A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by laboratory trial mixes.

B. Use a qualified independent testing agency, approved by the Engineer, for preparing and reporting proposed mix designs for the trial batch method.

1. Do not use Employer's field quality-control testing agency as the independent testing agency.

C. Proportion mixes to provide concrete with the following properties using test specimens prepared in accordance with ASTM C31/C31M and tested with ASTM C78/C78M:

C.1: Cement Concrete Pavement Layer:

1. Flexural Strength (28 Days): 4.6 MPa
2. Compressive Strength on cylinder (28 days): 35 MPA.
3. The minimum cementitious material content shall be 380 kg per cubic meter. The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than 0.4 by weight.
4. Slump Limit:
   - The mix determined shall be workable concrete having a slump for side-form concrete between 25 mm and 50 mm as determined by ASTM C143/C143M. A maximum slump of 100mm can be accepted for hand placed concrete.
5. Absorption and Permeability tests on hardened concrete: Water Absorption test to BS 1881-122 standard and Depth of Penetration Permeability test to BS EN 12390-8 standard should be carried out on hardened concrete at 28-days. The mean water absorption of the tested concrete shall not exceed 2% and the depth of penetration shall not exceed 15 mm.

D. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than Portland cement (if used) in concrete as follows:

1. Silica fume: 5% to 10%.

E. Air Entraining: Air-entraining admixture shall be added in such a manner that will insure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air-entrainment in the mix shall be in accordance with Table 3 plus or minus 1-1/2 percentage points. Air content shall be determined by testing in accordance with ASTM C231/C231M.

F. Add air-entraining admixture at manufacturer's prescribed rate to result in concrete at point of placement having an air content of 5.5 % for the 25mm Maximum Aggregate Size or 5.5% for the 19mm Maximum Aggregate Size.

G. Chemical Admixtures: Water-reducing and set-controlling admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, during the mix design, in accordance with ASTM C494/C494M.

H. Coloring Agent: Add coloring agent to mix (if required) according to manufacturer's written instructions.

I. Slip-form Construction: A high degree of uniformity in the plastic concrete is required. Caution should be exercised in establishing the air-entrainment percentage, as excessive air entrainment will aggravate edge slumping and insufficient air entrainment will result in poor concrete durability.

Some edge slump of the wet concrete behind the side form on the paving machine will occur, even with low slump concrete. This may continue, though very slowly, until initial set has taken place.

## 2.9 CONCRETE MIXING

A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94/C 94M and ASTM C1116/C1116M. Furnish batch certificates for each batch discharged and used in the Works.

1. When air temperature is between 30 deg C and 32 deg C, reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 32 deg C, reduce mixing and delivery time to 60 minutes.

B. Project-Site Mixing: Comply with requirements and measure, batch, and mix concrete materials and concrete according to ASTM C94/C94M. Mix concrete materials in appropriate drum-type batch machine mixer.

1. For mixers of 0.76 cu. m or smaller capacity, continue mixing at least one and one-half minutes, but not more than five minutes after ingredients are in mixer, before any part of batch is released.
2. For mixers of capacity larger than 0.76 cu. m, increase mixing time by 15 seconds for each additional 0.76 cu. m.
3. Provide batch ticket for each batch discharged and used in the Works, indicating Project identification name and number, date, mix type, mix time, quantity, and amount of water added.

C. Concrete:

1. May be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum.
2. Ready-mixed concrete shall be mixed and delivered in accordance with the requirements of ASTM C94/C94M, except that the minimum required revolutions of the mixing speed for transit mixed concrete may be reduced to not less than that recommended by the mixer manufacturer.
3. The number of revolutions recommended by the mixer manufacturer shall be indicated on the manufacturer's serial plate attached to the mixer.
4. Furnish test data acceptable to Engineer verifying that the make and model of the mixer will produce uniform concrete conforming to the provisions of ASTM C 94/C 94M at the reduced number of revolutions shown on the serial plate.

D. When mixed at the work site or in a central mixing plant, the mixing time shall not be less than 50 seconds nor more than 90 seconds. Mixing time ends when the discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

E. Mixer:

1. Operated at the drum speed as shown on the manufacturer's nameplate on the approved mixer. Any concrete mixed less than the specified time shall be discarded at own expense.
2. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meters, as shown on the manufacturer's standard rating plate on the mixer.
3. An overload up to 10 percent above the mixer's nominal capacity may be permitted provided concrete test data for segregation and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

F. Batch: Charged into the drum so that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform, and all water shall be in the drum by

the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as may restrict the free flow of materials into the drum.

G. Mixed Concrete:

1. Central mixing plant concrete shall be transported in truck mixers, truck agitators, or non-agitating trucks.
2. The time elapsing from the time water is added to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 45 minutes when the concrete is hauled in truck mixers or truck agitators. All these operations must be performed within 45 minutes after the initial mixing operations and the water-cement ratio must not be exceeded.
3. Admixtures for increasing the workability or for accelerating the set will be permitted only when specified for in the contract.

2.10 LIMITATIONS OF MIXING:

A. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

B. Unless authorized in writing by Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 4 deg. C and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 2 deg C.

C. When concreting is authorized during cold weather the temperature of the mixed concrete shall not be less than 10 deg. C at the time of placement in the forms.

D. During periods of hot weather when the maximum daily air temperature exceeds 30 deg C, the following precautions should be taken: the forms and/or the underlying material shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 32 deg. C. The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum. Refer to ACI 305R “Guide to Hot Weather Concreting”.

PART 3 - EXECUTION

3.1 PREPARATION

A. Proof-roll prepared subbase surface to check for unstable areas and verify need for additional compaction. Proceed with pavement only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.

B. Remove loose material from compacted subbase surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for paving to required lines, grades, and elevations. Install forms to allow continuous progress of work and so that forms can remain in place at least 24 hours after concrete placement.

B. Forms shall be securely set so that they can withstand impacts and vibration of consolidating and finishing equipment without visible spring or settlement. Extend flange braces on the base outward for not less than two thirds of the height of the form. Remove bent, twisted or broken forms, and forms with damaged top surfaces. Use of repaired forms only with inspection and approval. Built-up forms will not be allowed, unless specifically approved. The top faces of forms are not to vary from a true plane by more than 3 mm in 3m. The upstanding leg shall be perpendicular to the base and is not to vary horizontally from true alignment by more than 6 mm at any point. The ends of abutting sections locks together tightly for secure setting. Local defects, such as kinks in steel forms, will not be allowed.

C. Setting: Forms shall be set ahead of concrete placement and staked into place with at least three pins for each 3-m section. A pin shall be placed at each side of every joint. Form sections shall be tightly locked and free from movement in any direction. Excessive settlement or springing from operation of the finishing machine will not be allowed. Forms shall be cleaned and oiled before concrete placement.

1. The alignment and grade elevations of the forms shall be checked, and corrections made immediately before placing concrete. Reset and recheck forms when they have been disturbed, or when the grade has become unstable.

D. Clean forms after each use and coat with form release agent as required to ensure separation from concrete without damage.

E. Removal: Do not remove forms until the concrete has set for at least 12 hours, unless otherwise approved or where auxiliary forms are used temporarily in widened areas. Remove forms carefully to avoid damaging the pavement, and after removal, the side of the slab shall be cured by the method specified in Article 3.9.

## 3.3 STEEL REINFORCEMENT

A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating reinforcement and with recommendations in CRSI's "Placing Reinforcing Bars" for placing and supporting reinforcement.

B. Clean reinforcement of loose rust and mill scale, earth, or other bond-reducing materials.

C. At the time concrete is placed the reinforcing bars shall be free of mud, oil or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale, or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM specification requirements.

D. Accurately position, support, and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing bars by metal chairs, runners, bolsters, spacers, and hangers, as required.

E. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces. Maintain minimum cover to reinforcement.

F. Install welded wire fabric in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

G. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 50-mm overlap to adjacent mats.

## 3.4 PLACEMENT OF REINFORCEMENT

A. Reinforced Concrete Pavement: Comply with Concrete Reinforcing Steel Institute's recommended practice for "Placing Reinforcing Bars", for details and methods of reinforcement placement and supports, and as herein specified:

1. At the time concrete is placed the reinforcing bars shall be free of mud, oil or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale, or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM specification requirements.
2. Accurately position, support, and secure reinforcement against displacement by formwork, construction, or concrete placement operations. Locate and support reinforcing bars by metal chairs, runners, bolsters, spacers, and hangers, as required.
3. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement operations. Set wire ties so ends are directed into concrete, not toward exposed concrete surfaces.
4. Install welded wire fabric in as long lengths as practicable. Lap adjoining pieces at least one full mesh and lace splices with wire. Offset end laps in adjacent widths to prevent continuous laps in either direction.

## 3.5 JOINTS

A. General: Construct construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.

1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.

B. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour, unless pavement terminates at isolation joints.

1. Provide preformed galvanized steel or plastic keyway-section forms or bulkhead forms with keys, unless otherwise indicated. Embed keys at least 38 mm into concrete.
2. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
3. Provide tie bars at sides of pavement strips where indicated.
4. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
5. Use epoxy bonding adhesive at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.

C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.

1. Locate expansion joints at intervals indicated on drawings.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler less than 12 mm or more than 25 mm below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Longitudinal and Transverse Joints: Constructed as indicated on the plans and in accordance with the following requirements:

1. All joints shall be constructed true to line with their faces perpendicular to the surface of the pavement.
2. Joints shall not vary more than 12mm from a true line or from their designated position.
3. The vertical surface of the pavement adjacent to all expansion joints shall be finished to a true plane and edged to a radius of 6mm or as shown on the plans.
4. The surface across the joints shall be tested with a 3m straightedge as the joints are finished and any irregularities in excess of 6mm shall be corrected before the concrete has hardened.
5. Transverse joints shall be at right angles to the centerline of the pavement and shall extend the full width of the slab.
6. The transverse joints in succeeding lanes shall be placed in line with similar joints in the first lane. All joints shall be so prepared, finished, or cut to provide a groove of the width and depth shown on the plans.

E. Slip-Form Construction: Transverse joints with dowels will require particular care to insure the dowels are accurately placed and not disturbed during concrete placement.

1. Transverse dowels will require use of an apparatus to firmly hold the dowels perpendicular to the joint and parallel to the slab surface.
2. During the concrete placement operation, it is advisable to place plastic concrete directly on the dowel assembly immediately prior to passage of the paver to help maintain dowel alignment.

F. Tie Bars: Deformed bars installed principally in longitudinal joints as shown on the plans.

1. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on Drawings.
2. Tie bars shall be held in position parallel to the pavement surface and midway between the surfaces of the slab.
3. When tie bars extend into an unpaved lane, they may be bent at right angles against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified.
4. Tie bars shall not be painted, greased, or enclosed in sleeves.

G. Dowel Bars: Dowel bars or other load-transfer units of an approved type shall be placed across transverse or other joints in the manner as specified on the plans.

1. They shall be of the dimensions and spacing as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place.
2. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position.
3. A metal or other type dowel expansion cap of sleeve shall be furnished for each dowel bar used with expansion joints.
4. These caps shall be substantial enough to prevent collapse and shall be placed on the ends of the dowels as shown on the plans.
5. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight.
6. The portion of each dowel painted with rust preventative paint and shall be thoroughly coated with asphalt MC-70, or an approved lubricant, to prevent the concrete from binding to that portion of the dowel.

H. Install dowel bars and support assemblies at joints where indicated. Lubricate or asphalt-coat one-half of dowel length to prevent concrete bonding to one side of joint.

I. Joints Installation:

1. The top of an assembled joint device shall be set at the proper distance below the pavement surface and the elevation shall be checked. Such devices shall be set to the required position and line and shall be securely held in place by stakes or other means during the pouring and finishing of the concrete. The pre-moulded joint material shall be placed and held in a vertical position; if constructed in sections, there shall be no offsets between adjacent units. Dowel bars shall be checked for exact position and alignment as soon as the joint device is staked in place, and the device shall be tested to determine whether it is firmly supported. The maximum permissible tolerance on dowel bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 6mm per 300 mm of a dowel bar. The most effective way to obtain proper alignment is with well-fabricated dowel baskets and dowel assemblies.

2. When joints in concrete pavements are sawed, the joints shall be cut as shown on the plans. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 3mm wide so as to provide proper shape factor W/D for optimum performance in accordance with the manufacturer recommendations as shown on the plans. The groove edges shall be 6mm by 6mm chamfered or smoothed by a radius of 6mm to form a “bull nose” shape, depending on the type of joint and as shown on the drawings. When shown on the plans or required by the specifications, the top portion of the slot groove shall be widened by means of a second shallower cut or by suitable and approved beveling to provide adequate space for joint sealers. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing. Sawing shall be carried on both during the day and night as required. The joints shall be sawed at the required spacing consecutively in sequence of the concrete placement, unless otherwise approved by Engineer.

J. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows:

1. Grooved Joints: Form contraction joints after initial floating by grooving and finishing each edge of joint with groover tool to the radius shown on drawings. Repeat grooving of contraction joints after applying surface finishes. Eliminate groover marks on concrete surfaces.

2. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut joints into concrete to the width shown on drawings, when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

K. Longitudinal Joints:

1. Construction Type: Longitudinal construction joints necessary for lane construction shall be formed against suitable side forms as indicated in the plans. Wooden forms may be used under special conditions, when approved by Engineer. Where butt-type joints with dowels are designated, the dowels for this type shall be painted and greased. The edges of the joint shall be finished with a grooving tool or edging tool, and a space or slot shall be formed along the joint of the dimensions, as indicated, to receive the joint sealing material. Longitudinal construction joints shall be sawed to provide a groove at the top conforming to the details and dimensions indicated on the plans. Provisions shall be made for the installation of tie bars as noted on the plans.

2. Contraction or Weakened - Plane Type: Longitudinal groove formed or sawed in the top of the slab shall be installed where indicated on the drawings. The groove shall be formed in the plastic concrete with suitable tools or material to obtain the width and depth specified, or it shall be sawed with approved equipment in the hardened concrete to the dimensions required. When the groove is formed in plastic concrete, it shall be true to line with not more than 6mm variation in 3m; it shall be uniform in width and depth; and the sides of the groove shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The sawed

groove shall be straight and of uniform width and depth. In either case, the groove shall be clean cut so that spalling will be avoided at intersections with transverse joints. Tie bars shall be installed across these joints where indicated on the plans.

3. Expansion Type: Longitudinal expansion joints shall be installed as indicated on the plans. The pre-moulded filler, of the thickness as shown on the plans, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A metal cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the pre-moulded filler. The edge of the joint shall be finished and tooled while the concrete is still plastic.

L. Transverse Joints:

1. Expansion Type:

a. Transverse expansion joints shall be installed at the locations and spacing as shown on the plans. The joints shall be installed at right angles to the centerline and perpendicular to the surface of the pavement. The joints shall be installed and finished to insure complete separation of the slabs. Expansion joints shall be of a pre-moulded type conforming to these specifications and with the plans and shall be the full width of the pavement strip.

b. All concrete shall be cleaned from the top of the joint material. Before the pavement is opened to traffic, this space shall be swept clean and filled with approved joint sealing material.

c. All devices used for the installation of expansion joints shall be approved by Engineer. They shall be easily removable without disturbing the concrete and held in proper transverse and vertical alignment. Immediately after forms are removed, any concrete bridging the joint space at the ends shall be removed for the full width and depth of the joint.

d. When specified, expansion joints shall be equipped with dowels of the dimensions and at the spacing and location indicated on the plans. The dowels shall be firmly supported in place and accurately aligned parallel to the subgrade and the centerline of the pavement by means of a dowel assembly, which will remain in the pavement and will ensure that the dowels are not displaced during construction.

2. Contraction Type: Transverse contraction joints, weakened-plane joints, or both, shall be installed at the locations and spacing as shown on the plans. These joints will be installed by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened in the same manner as specified. Dowel bar assemblies shall be installed as shown on the plans.

3. Construction Type: Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. When the installation of the joint can be planned in advance, it shall be located at a contraction or expansion joint. The joint shall not be allowed within 2500 mm of a regular spaced transverse joint. If the pouring of the concrete has been stopped, causing a joint to fall within this limit, it shall not be installed, and the fresh placed concrete shall be removed back to the 2500 mm limit.

M. Edging: Tool edges of pavement, gutters, curbs, and joints in concrete after initial floating with an edging tool to the radius shown on drawings. Repeat tooling of edges after applying surface finishes. Eliminate tool marks on concrete surfaces.

## 3.6 CONDITIONING OF UNDERLYING COURSE, SLIP-FORM CONSTRUCTION:

A. The base course on which the pavement will be placed shall extend approximately 900 mm beyond the paving machine track to support the paver without any noticeable deformation. Where necessary, the base course will be extended at own expense.

B. If damage occurs to the base course, it shall be corrected full depth or the damaged areas filled with concrete integral with the pavement. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete.

C. The prepared grade shall be well moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. In cold weather the underlying base course shall be protected so that it will be entirely free of frost when concrete is placed.

3.7 CONDITIONING OF UNDERLYING COURSE, SIDE-FORM CONSTRUCTION:

A. Prepared Grade: Well moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete.

B. If damage occurs to the base course, it shall be corrected full depth, or the damaged areas filled with concrete integral with the pavement.

C. A multiple-pin template weighing not less than 454 kg per 6 m or other approved template shall be provided and operated on the forms immediately in advance of the placing of the concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying course. The adjustment and operation of the template shall be such as will provide an accurate re-test of the grade before placing the concrete thereon. All excess material shall be removed. Low areas may be filled with concrete integral with the pavement.

3.8 HANDLING, MEASURING, AND BATCHING MATERIAL

A. Batch Plant Site: Layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work.

B. Stockpiles: Built up in layers of not more than 900 mm in thickness. Each layer shall be completely in place before beginning the next layer and shall not be allowed to "cone" down over the next lower layer. Aggregates from different sources and of different grading shall not be stockpiled together. Improperly placed stockpiles will not be accepted by Engineer.

C. Aggregates: Handled from stockpiles or other sources to the batching plant in such manner to secure the specified grading of the material. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched.

D. Cement: Stored in weather tight structures with raised floors or in suitable silos. Different consignments of bagged cement shall be used separately and in the order of delivery. If, for any reason, cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used. Also, cement manufactured more than twelve months prior to proposed use on site shall not be used.

E. Aggregate: Fine and coarse aggregate shall be separately weighed into hoppers in the respective amounts set by Engineer in the job mix. Cement shall be measured by weight. Separate scales and hopper, with a device to positively indicate the complete discharge of the batch of cement into the batch box or container, shall be used for weighing the cement.

F. When required by the contract or when permitted, batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type.

G. Water: Measured either by volume or by weight. The accuracy of measuring the water shall be within plus or minus 1 percent of required amounts. Unless the water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

H. Methods and equipment for adding air-entraining agent or other admixtures to the batch, when required, shall be approved by Engineer. All admixtures shall be measured into the mixer with an accuracy of plus or minus 3 percent.

## 3.9 CONCRETE PROTECTION AND CURING

A. General: Protect concrete against loss of moisture and rapid temperature changes for at least seven days from beginning of the curing operation. Unhardened concrete shall be protected from rain and flowing water. All equipment needed for adequate curing and protection of the concrete shall be on hand, ready to use before concrete placement beings. A standby water truck capable of dispensing a fine spray of water shall be continuously available during paving operations to keep the concrete moist until the curing compound has been applied. Provide protection as necessary to prevent cracking of the pavement due to temperature changes during the curing period.

B. Membrane Curing: Apply a uniform coating of white pigmented-type membrane curing compound to the entire exposed surface of the concrete by means of an approved automatic spraying machine as soon after finished as free water has disappeared from the finished surface. Coated formed surfaces immediately after the forms are removed and in no case longer than one hour after removal of forms. Do not allow concrete to dry before the application of the membrane. Moisten the surface of the concrete with a fine spray of water and apply curing compound as soon as the free water disappears, if any drying has occurred. The spraying machine shall be self-propelled and ride on the side forms, or previously constructed pavement straddling the newly paved lane. The machine is to have one or more spraying nozzles that can be controlled and operated to completely and uniformly cover the pavement surface with the required amount of curing compound. Thoroughly and continuously agitated curing compound in the drum used for the spraying operation mechanically throughout the full depth of the drum during application. Air agitation may be used only to supplement mechanical agitation. Provide sufficient spraying pressure to produce a fine spray as necessary to cover the surface thoroughly and completely with a uniform film. Maintain spray equipment in good mechanical condition, and provide adequate wind guard to the spray nozzle. Apply curing compound with an overlapping coverage that will give a two-coat application at a coverage rate of not more than 0.1 L/sq. m for each coat or as recommended by the manufacturer. The application of curing compound by hand-operated pressure sprayers will be permitted only on odd widths or shapes of slabs as approved, and on concrete surfaces exposed by removal of forms. Apply the second coat, when application is made by hand-operated sprayer, in a direction approximately at right angles to the direction of the first coat. The compound is to form a uniform, continuous, cohesive film that will not check, crack or peel, and is free of pinholes and other discontinuities. Apply an additional coat, if pinholes, abrasions or other discontinuities exist, to the affected areas within 30 minutes. Respray concrete surfaces that are subjected to heavy rainfall or abrasive windblown sand within three hours after rainfall or abrasive windblown sand within three hours after the curing compound has been applied as specified above. Respray areas where the curing membrane is damaged by subsequent construction operations within the curing period.

1. Precautions shall be taken to ensure that concrete is properly cured at sawed joints, but that no curing compound enters the joints. Tightly seal top of joint opening and joint groove at exposed edges before concrete adjacent to the joint is resprayed. Sealing joint groove by

using method that will prevent loss of moisture from the joint during the specified curing period.

2. Provide approved standby facilities for during concrete pavement at an accessible location at the jobsite for use in the event of mechanical failure of the spraying equipment, or other conditions that might prevent correct application of curing compound at the proper time.
3. Protect concrete surfaces to which curing compounds have been applied during the curing period from pedestrian and vehicular traffic except as required of joint-sawing operations and surface testing, and from any other possible damage to the continuity of the membrane.

C. Protection: Protect pavement and its appurtenances from damage caused by all traffic. The Engineer will decide when the pavement may be cleaned and opened to traffic, but not earlier than 14 days after concrete placing. Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with the recommendations of ACI 306R for cold weather protection and ACI 305R for hot weather protection during curing.

## 3.10 CONCRETE PLACEMENT

A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.

B. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.

C. Comply with requirements and with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.

D. Do not add water to concrete during delivery, at Project site, or during placement.

E. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

F. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete according to recommendations in ACI 309R.

1. Consolidate concrete along face of forms and adjacent to transverse joints with an internal vibrator. Keep vibrator away from joint assemblies, reinforcement, or side forms. Use only square-faced shovels for hand-spreading and consolidation. Consolidate with care to prevent dislocating reinforcement, dowels, and joint devices.

G. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats (if any) immediately in final position. Place top layer of concrete, strike off, and screed.

1. Remove and replace portions of bottom layer of concrete that have been placed more than 15 minutes without covered by top layer, or use bonding agent if approved by Engineer.

H. Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the plans.

I. Screed pavement surfaces with a straightedge and strike off. Commence initial floating using bull floats or darbies to form an open textured and uniform surface plane before excess moisture or bleed

water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading dry-shake surface treatments.

J. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.

K. Side Form Method:

1. The concrete shall be deposited on the moistened grade to require as little re-handling as possible. Unless truck mixers, truck agitators, or non agitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade to prevent segregation of the materials. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Necessary hand spreading shall be done with shovels - not rakes. Workmen shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.
2. When concrete is to be placed adjoining a previously constructed lane of pavement and when mechanical equipment will be operated upon the existing lane of pavement, the concrete shall be at least 7 days old and at a flexural strength approved by Engineer.
3. Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 15 seconds in any one location, nor shall the vibrators be used to move the concrete.
4. Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is well centered on the joint assembly.
5. Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by approved methods.

L. Slip-Form Method:

1. The concrete shall be placed with an approved crawler-mounted, slip-form paver designed to spread, consolidate, and shape the freshly placed concrete in one complete pass of the machine so that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformance with requirements of the plans and specifications. The concrete should be placed directly on top of the joint assemblies to prevent them from moving when the paver moves over them. Side forms and finishing screeds shall be adjustable to the extent required to produce the specified pavement edge and surface tolerance. The side forms shall be of dimensions, shape, and strength to support the concrete laterally for a sufficient length of time so that no appreciable edge slumping will occur. Final finishing shall be accomplished while the concrete is still in the plastic state.

2. All joints, and particularly all longitudinal joints, shall meet the specified tolerance throughout their length. In the event that slumping or sloughing occurs behind the paver or if there are any other structural or surface defects, which, in the opinion of Engineer, cannot be corrected within permissible tolerances, Engineer may halt paving operations until proper adjustment of the equipment or procedures have been made. In the event that satisfactory procedures and pavement are not achieved after not more than 600 m of single lane paving, the balance of the work shall be completed with the use of standard metal forms and the formed method of placing and curing.

M. Slip-Form Pavers: When automatic machine placement is used for pavement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce pavement to required thickness, lines, grades, finish, and jointing as required for formed pavement.

1. Compact base and subbase, and prepare subgrade of sufficient width to prevent displacement of paver machine during operations.

N. When adjoining pavement lanes are placed in separate pours, do not operate equipment on concrete until pavement has attained 85 percent of its 28-day compressive strength.

O. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 32 deg C. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is subject to the approval of the Engineer.
2. Cover reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.
4. Concreting shall not be permitted when the rate of evaporation exceed 1.0 kg/m$^2$/hr. (ACI 305R "Guide to Hot Weather Concreting").

## 3.11 CONCRETE FINISHING

A. General: Wetting of concrete surfaces during screeding, initial floating, or finishing operations is prohibited.

B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and the concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats, or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots, and fill low spots. Refloat surface immediately to uniform granular texture.

1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
2. Medium-to-Fine-Textured Broom Finish: Draw a soft bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1.6 to 3 mm deep with a stiff-bristled broom, perpendicular to line of traffic.

## 3.12 FINAL STRIKE-OFF, CONSOLIDATION AND FINISHING

A. Sequence: The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight edging, and final surface finish. The addition of superficial water to the surface of the concrete to assist in finishing operations generally will not be permitted. If the application of water to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

B. Strike-Off of Concrete: Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the plans and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the plans.

C. Finishing at Joints:

1. The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation

under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement.

2. Concrete adjacent to joints shall be mechanically vibrated. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints.
3. If uninterrupted operations of the finishing machine, to, over, and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 200mm from the joint.
4. Segregated concrete shall be removed from the front of and off the joint, the screed shall be lifted and set directly on top of the joint, and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

D. Machine Finishing:

1. The concrete shall be spread as soon as it is placed, and it shall be struck off and screeded by an approved finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give the proper consolidation and to leave a surface of uniform texture.
2. Excessive operation over a given area shall be avoided. When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length.
3. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

E. Hand Finishing:

1. Hand finishing methods will not be permitted, except under the following conditions:
   a. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade;
   b. In areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical.
2. Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete when reinforcement is used.
3. The screed for the surface shall be at least 600 mm longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Consolidation shall be attained by the use of a suitable vibrator.

F. Floating: After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a longitudinal float, using approved hand or machine methods.

G. Straight-Edge Testing and Surface Correction:

1. After the pavement has been struck off and consolidated and while the concrete is still plastic, it shall be tested for trueness with a 4.8m straightedge. Furnish and use an accurate 4.8m straightedge swung from handles 900 mm longer than one-half the width of the slab.
2. The straightedge shall be held in contact with the surface in successive positions parallel to the centreline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of

the straightedge. Any excess water and laitance shall be removed from the surface of the pavement.

3. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished.
4. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross section.
5. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

## 3.13 SPECIAL FINISHES

A. Monolithic Exposed Aggregate Finish: Expose coarse aggregate to pavement surfaces as follows:

1. Immediately after floating, spray-apply chemical surface retarder to pavement according to manufacturer's written instructions.
2. Cover with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
3. Without dislodging aggregate, remove excess mortar by lightly brushing surface with a stiff, nylon bristle broom.
4. Fine-spray surface with water and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.

B. Seeded Exposed Aggregate Finish: Immediately after floating, broadcast a single layer of aggregate uniformly onto the pavement surface. Tamp seeded aggregate into plastic concrete, and float to entirely embed aggregate with mortar cover of 1.6 mm.

1. Spray-apply chemical surface retarder to pavement according to manufacturer's written instructions.
2. Cover pavement surface with plastic sheeting, sealing laps with tape, and remove when ready to continue finishing operations.
3. Without dislodging aggregate, remove excess mortar by lightly brushing surface with a stiff, nylon bristle broom.
4. Fine-spray surface with water and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required.

C. Slip-Resistant Aggregate Finish: Before final floating, apply slip-resistant aggregate finish to pavement surfaces according to manufacturer's written instructions and as follows:

1. Uniformly spread 12 kg/10 sq. m of dampened nonslip aggregate over the surface. Tamp aggregate flush with surface using a steel trowel, but do not force below surface.
2. After curing, lightly work surface with a steel wire brush or an abrasive stone, and water to expose nonslip aggregate.

D. Rock-Salt Finish: After initial floating, uniformly seed 0.2 kg/10 sq. m over the concrete surface.

1. Cover surface with 0.025-mm thick polyethylene sheet and remove when concrete has hardened and seven-day curing period has elapsed.
2. Embed rock salt into plastic concrete, power float concrete, and trowel finish.
3. After seven-day curing period, saturate concrete with water and broom-sweep surface to dissolve remaining rock salt.

E. Colored Dry-Shake Hardener Finish: After initial floating, apply colored dry-shake materials to pavement surfaces according to manufacturer's written instructions and as follows:

1. Uniformly apply colored dry-shake materials at a rate of 49 kg/10 sq. m, unless greater amount is recommended by manufacturer to match pavement color required.
2. Uniformly distribute approximately two-thirds of colored dry-shake material over the concrete surface with mechanical spreader, and embed by power floating. Follow power floating with a second shake application, uniformly distributing remainder of dry-shake material to ensure uniform color, and embed by power floating.
3. After final floating, apply a hand-trowel finish followed by a broom finish to concrete. Cure concrete with curing compound recommended by dry-shake material manufacturer. Apply curing compound immediately after final finishing.

3.14 SURFACE TEXTURE:

A. Brush or Broom Finish:

1. A brush or broom finish shall be applied to all newly constructed concrete pavements when the water sheen has practically disappeared.
2. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 2 mm in depth.
3. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected.

3.15 SKID RESISTANT SURFACES:

A. Wire Combing: A skid resistant surface shall be provided by wire combing in plastic concrete. The wire combing technique shall use steel combs or tines of various dimensions to form groove-like texture in the plastic concrete pavement and shall provide grooves that are approximately 3 mm by 3 mm spaced 13 mm centre-to-centre.

3.16 SURFACE TEST:

A. As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 4.8 m straightedge or other specified device. Areas in a slab showing high spots of more than 6 mm but not exceeding 12 mm in 4.8 m shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 6 mm or less. Where the departure from correct cross section exceeds 12 mm, the pavement shall be removed and replaced at own expense when so directed by Engineer.

B. Any area or section so removed shall not be less than 3 m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3 m in length shall also be removed and replaced.

3.17 REMOVING FORMS

A. Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has set for at least 12 hours, except where auxiliary forms are used temporarily in widened areas. Forms shall be removed carefully to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured. Major honeycombed areas shall be considered as defective work and shall be removed and replaced. Any area or section so removed shall not be less than 3 m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3 m in length shall also be removed and replaced.

## 3.18 SEALING JOINTS

A. The joints in the pavement shall be sealed as shown on Drawings and as specified in Section 609.

## 3.19 OPENING TO TRAFFIC

A. Engineer shall decide when the pavement shall be opened to traffic. The pavement will not be opened to traffic until test specimens moulded and cured in accordance with ASTM C31/C31M have attained the specified flexural strength when tested in accordance with ASTM C78/C78M, unless otherwise acceptable to Engineer.

## 3.20 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 6 mm.
2. Thickness: Plus 9 mm, minus 6 mm.
3. Surface: Gap below 3-m long, unleveled straightedge not to exceed 6 mm.
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 25 mm.
5. Vertical Alignment of Tie Bars and Dowels: 6 mm.
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 13 mm.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 6 mm per 300 mm.
8. Joint Spacing: 75 mm.
9. Contraction Joint Depth: Plus 6 mm, no minus.
10. Joint Width: Plus 3 mm, no minus.

B. Extreme care must be exercised in all phases of the operation to assure the pavement will pass the specified tolerances. The following tolerances are applicable:

1. Lateral deviation from established alignment of the pavement edge shall not exceed plus or minus 30 mm in any lane.
2. Vertical deviation from established grade shall not exceed plus or minus 12 mm at any point.
3. Surface smoothness deviations shall not exceed 6 mm from a 4.8 m straightedge placed in any direction, including placement along and spanning any pavement joint or edge.

## 3.21 WHEEL STOPS

C. Securely attach wheel stops into pavement with not less than two galvanized steel dowels embedded in holes cast into wheel stops. Firmly bond each dowel to wheel stop and to pavement. Extend upper portion of dowel 125 mm into wheel stop.

## 3.22 FIELD QUALITY CONTROL

A. Slump: One test at point of discharge for each day's pour of concrete. Additional tests when concrete consistency seems to have changed.

B. Concrete Temperature: Test hourly when air temperature is 4 deg C and below, and when 27 deg C and above, and each time a set of flexural test beams are made.

C. Flexural Strength:

1. Flexural test beams shall be made for each day's pour exceeding 4 cu.m, plus additional sets for each 40 cu.m over and above the first 20 cu. m. Each group of test beams shall be moulded

from the same batch of concrete and shall consist of a sufficient number of specimens to provide two flexural strength tests at each test age. The specimens shall be made in accordance with ASTM C31/C31M. However, at the start of paving operations and when the aggregate source, aggregate characteristics, or mix design is changed, additional groups of test beams may be required until Engineer is satisfied that the concrete mixture being used complies with the strength requirements of these specifications. Test ages will be 7 days and 28 days.

2. The flexural strength of the concrete shall meet the following requirements:

   a. The average of any 4 consecutive strength tests, tested at the end of 28 days, shall have an average flexural strength equal to or greater than the specified flexural strength;
   b. Not more than 20 percent of the beams tested at the end of 28 days shall have a flexural strength less than the specified strength;
   c. No specimen shall have a flexural strength less than 90% of the specified flexural strength.

3. Specimens, which are obviously defective, shall not be considered in the determination of the strength. When it appears that the test specimens will fail to conform to the requirements for strength, Engineer shall have the right to order changes in the concrete sufficient to increase the strength to meet the requirements. When a satisfactory relationship between 7-days and 28-day strengths has been established and approved, the 7-day test results may be used as an indication of the 28-day strengths. However, the 7-day test results will not replace the results of the 28-day tests if the 28-day results fall below the requirements.

D. Testing Agency: Engage a qualified independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement according to requirements specified in this Article.

E. Testing Services: Testing shall be performed according to the following requirements:

1. Sampling Fresh Concrete: Representative samples of fresh concrete shall be obtained according to ASTM C172/C172M, except modified for slump to comply with ASTM C 94.
2. Slump: ASTM C143/C143M; one test at point of placement for each flexural and/or compressive-strength test, but not less than one test for each day's pour of each type of concrete. Additional tests will be required when concrete consistency changes.
3. Air Content: ASTM C231/C231M, pressure method; one test for each flexural and/or compressive strength test, but not less than one test for each day's pour of each type of air-entrained concrete.
4. Concrete Temperature: ASTM C1064/C1064M; one test hourly when air temperature is 4.4 deg C and below and when 27 deg C and above, and one test for each set of flexural and/or compressive-strength specimens.
5. Compression Test Specimens: ASTM C31/C31M; one set of four standard cylinders for each compressive-strength test, unless otherwise indicated. Cylinders shall be molded and stored for laboratory-cured test specimens unless field-cured test specimens are required.
6. Compressive-Strength Tests: ASTM C39/C39M; one set for each day's pour of each concrete class exceeding 4 cu. m, but less than 19 cu. m, plus one set for each additional 38 cu. m. One specimen shall be tested at 7 days and two specimens at 28 days; one specimen shall be retained in reserve for later testing if required.
7. When frequency of testing will provide fewer than five compressive-strength tests for a given class of concrete, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.
8. When total quantity of a given class of concrete is less than 38 cu. m, Engineer may waive compressive-strength testing if adequate evidence of satisfactory strength is provided.
9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, current operations shall be evaluated and corrective procedures shall be provided for protecting and curing in-place concrete.
10. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive compressive-strength test results equal or exceed specified compressive strength

and no individual compressive-strength test result falls below specified compressive strength by more than 3.4 MPa.

11. Water Absorption and Depth of Penetration Testing: BS 1881 and BS EN 12390-8; minimum of four standard cylinders shall be obtained at the start of concreting works for each permeability test, unless otherwise indicated by the Engineer.

F. Test results shall be reported in writing to Engineer, concrete manufacturer, and Contractor within 24 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing agency, concrete type and class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

G. Additional Tests: Testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Engineer. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed.

## 3.23 REPAIRS AND PROTECTION

A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.

B. Drill test cores where directed by Engineer when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with Portland cement concrete bonded to pavement with epoxy adhesive.

C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Taking Over inspections.

END OF SECTION 608

# SECTION 609 - CONCRETE PAVING JOINT SEALANTS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Particular Conditions and Division 1 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. This Section includes the following:

1. Cold-applied joint sealants.
2. Hot-applied joint sealants.
3. Fuel-resistant joint sealants.
4. Expansion, construction and contraction joints within cement concrete pavement.
5. Joints between cement concrete and asphalt pavement.

B. Related Sections include the following:

1. Section J31 "Movement Joints" for sealing non-traffic and traffic joints in locations not specified in this Section.
2. Section 608 "Concrete Paving" for constructing joints in concrete pavement.

### 1.3 SUBMITTALS

A. Joint Sealers: Produced and installed to establish and maintain watertight and air tight continuous seals.

B. Samples for Initial Selection Purposes: Manufacturer’s standard bead samples consisting of strips of actual products showing full range of colors available, for each product exposed to view.

C. Samples for Verification: For each type and color of joint sealant required. Install joint-sealer samples in 6-mm wide joints formed between two 150-mm long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.

D. Product Certificates: Signed by manufacturers of joint sealants certifying that products furnished comply with requirements and are suitable for the use indicated.

E. Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of engineers and employers, and other information specified or required by Engineer.

F. Compatibility and Adhesion Test Reports: From joint elastomeric sealant manufacturer indicating the following:

1. Materials forming joint substrates and elastomeric backer materials have been tested for compatibility and adhesion with joint sealants.
2. Interpretation of test results and written recommendations for primers and substrate preparation needed for adhesion.

G. Product Test Reports: From a qualified testing agency indicating joint sealants comply with requirements, based on comprehensive testing of current product formulations.

H. Preconstruction Field Test Report: Indicating which products and joint preparation methods demonstrated acceptable adhesion to joint substrates.

## 1.4 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer who has specialized in installing joint sealants similar in material, design, and extent to those indicated for this Project and whose work has resulted in joint-sealant installations with a record of successful in-service performance.

B. Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.

C. Product Testing: Obtain test results for "Product Test Reports" mentioned in "Sub-Article 1.3.G above" from a qualified testing agency, based on testing current sealant formulations within a 36-month period.

1. Testing Agency Qualifications: An independent testing agency qualified according to ASTM C1021.
2. Sampling and testing of joint sealing material shall be in accordance with ASTM D5329.

D. Product Testing: Provide comprehensive test data for each type of joint sealer based on tests conducted by a qualified independent testing laboratory on current product formulations within a 24-month period preceding date of submittal of test results to Engineer.

1. Test elastomeric sealants for compliance with requirements specified by reference to ASTM C 920. Include test results for hardness, stain resistance, adhesion and cohesion under cyclic movement (per ASTM C719), low-temperature flexibility, modulus of elasticity at 100 percent strain, effects of heat aging, and effects of accelerated weathering.
2. For all exterior sealant systems, furnish test results performed on joint sealers after they have cured 1 year.

E. Preconstruction Compatibility and Adhesion Testing: Submit to joint sealant manufacturer, for testing indicated below, samples of materials that will contact or affect joint sealants.

1. Use manufacturer's standard test methods to determine whether priming and other specific joint preparation techniques are required to obtain rapid, optimum adhesion of joint sealants to joint substrates.
    a. Perform tests under environmental conditions replicating those that will exist during installation.
2. Submit not less than nine pieces of each type of material, including joint substrates, shims, joint-sealant backer materials, secondary seals, and miscellaneous material.
3. Schedule sufficient time for testing and analyzing results to prevent delaying the Works.
4. Investigate materials failing compatibility or adhesion tests and obtain joint sealer manufacturer's written recommendations for corrective measures, including use of specially formulated primers.
5. Testing will not be required if joint sealant manufacturer submits joint preparation data that are based on previous testing of current sealant products for adhesion to, and compatibility with, joint substrates and other materials matching those submitted.

F. Preconstruction Field Testing: Prior to installation of joint sealants, field-test their adhesion to joint substrates as follows:

1. Locate test joints where indicated or, if not indicated, as directed by Engineer.
2. Conduct field tests for each application indicated below:

a. Each type of elastomeric sealant and joint substrate indicated.
b. Each type of non-elastomeric sealant and joint substrate indicated.

3. Arrange for tests to take place in presence of Engineer.

4. Test Method: Test joint sealers by hand pull method described below:

a. Install joint sealants in 1500mm joint lengths using same materials and methods for joint preparation and joint sealant installation required for completed Works. Allow sealants to cure fully before testing.
b. Make knife cuts as follows: A horizontal cut from one side of joint to the other followed by 2 vertical cuts approximately 50mm long at side of joint and meeting horizontal cut at top of 50mm cuts. Place a mark 25 mm from top of 50 mm piece.
c. Use fingers to grasp 50mm piece of sealant just above 25mm mark; pull firmly down at a 90 degree angle or more while holding a ruler along side of sealant. Pull sealant out of joint to the distance recommended by sealant manufacturer for testing adhesive capability, but not less than that equaling specified maximum movement capability in extension; hold this position for 10 seconds.

5. Report whether or not sealant in joint connected to pull out portion failed to adhere to joint substrates or tore cohesively. Include data on pull distance used to test each type of product and joint substrate.

6. Evaluation of Field Test Results: Sealants not evidencing adhesive failure from testing, in absence of other indications of noncompliance with requirements, will be considered satisfactory. Do not use sealants, which fail to adhere to joint substrates during testing.

G. Field-Constructed Mock-Ups: Prior to installation of joint sealers, apply elastomeric sealants to the following selected pavement joints as indicated below for further verification of colors selected from sample submittals and to represent completed work for qualities of appearance, materials, and application:

1. Joints in field-constructed mock-ups of assemblies specified in other sections, which are indicated to receive elastomeric joint sealants specified in this section.
2. Retain mock-ups during construction as standard for judging completed construction.

## 1.5 DELIVERY, STORAGE, AND HANDLING

A. Deliver materials to Project site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration date, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle materials to comply with manufacturer's written instructions to prevent their deterioration or damage due to moisture, high or low temperatures, contaminants, or other causes.

## 1.6 PROJECT CONDITIONS

A. Environmental Limitations: Do not proceed with installation of joint sealants under the following conditions:

1. When ambient and substrate temperature conditions are outside limits permitted by joint sealant manufacturer.
2. When joint substrates are wet due to rain, condensation, or other causes.

B. Joint-Width Conditions: Do not proceed with installation of joint sealants where joint widths are less than that allowed by joint sealant manufacturer for application indicated.

C. Joint-Substrate Conditions: Do not proceed with installation of joint sealants until contaminants capable of interfering with their adhesion are removed from joint substrates.

D. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

## PART 2 - PRODUCTS

### 2.1 MATERIALS, GENERAL

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint sealant manufacturer based on testing and field experience.

B. Colors of Exposed Joint Sealants: Match Engineer's samples.

C. Colors of Exposed Joint Sealants: As indicated by referencing manufacturer's designations.

D. Colors of Exposed Joint Sealants: As selected by Engineer from manufacturer's full range for this characteristic.

### 2.2 ELASTOMERIC JOINT SEALANTS

A. ASTM D5893/D5893M, Type NS.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works, to the approval of the Engineer.

B. Single-Component, Self-Leveling, Silicone 3569 - Joint Sealant for Concrete: ASTM D5893/D5893M, Type SL.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works include, to the approval of Engineer.

C. Multi-component, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C920, Type M, Grade P, Class 25, for Use T.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works include, to the approval of Engineer.

### 2.3 HOT-APPLIED JOINT SEALANTS:

A. Hot-Applied, Single-Component Joint Sealant for Concrete and Asphalt: ASTM D6690, Types I, II, and III.

1. Products: Subject to compliance with requirements, provide available products that may be incorporated into the Works include, to the approval of the Engineer.

### 2.4 COLD-APPLIED JOINT SEALANTS:

A. Federal Specification SS-S-200–Joint Sealants, Cold-Applied, Two-Component, for Portland Cement Concrete Pavements Type M (Machine Application – Fast Curing)

B. ASTM D2628 - Preformed Polychloroprene Elastomeric Joint Sealants for Concrete Pavements.

1. For preformed joint sealer the manufacturer shall certify that the performed seal will exert a minimum pressure of 21 kPa when compressed to 80 percent of nominal width and a maximum of 172 kPa when compressed to 50 percent of nominal width.
2. Lubricant: Lubricant for installation of preformed joint seal shall be a one-component polychloroprene compound containing only soluble phenolic resins blended together with anti-oxidants and acid acceptors in aromatic hydrocarbon solvent mixture and shall meet the following requirements:

| | Requirements | Standard |
|---|---|---|
| Average weight per gallon | 7.8 [pounds] | |
| Solids content | 22-28 [percent by weight] | ASTM-D1644 ( Method A ) |
| Film strength | 2,300 min. [psi] | ASTM-D412 |
| Elongation | 750 min. [percent] | ASTM-D412 |

3. Each shipment of lubricant shall be delivered to the jobsite in the manufacturer's original sealed container. Each container shall be marked with the manufacturer's name, batch or lot number, and the date of manufacture and shall be accompanied by the manufacturer's certification stating that the lubricant meets the requirements of the specification.
4. This lubricant shall be stored at a temperature between 10° C and 30° C and shall be used within 270 days of its manufacture.

## 2.5 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are nonstaining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint sealant manufacturer based on field experience and laboratory testing.

B. Plastic Foam Joint Fillers: Preformed, compressible, resilient, nonwaxing, nonextruding strips of flexible, nongassing plastic foam of material indicated below; nonabsorbent to water and gas; and of size, shape and density to control sealant depth and otherwise contribute to producing optimum sealant performance.

1. Either open-cell polyurethane foam or closed-cell polyethylene foam, unless otherwise indicated, subject to approval of sealant manufacturer.

C. Bond-Breaker Tape: Polyethylene tape or other plastic tape as recommended by sealant manufacturer for preventing sealant from adhering to rigid, inflexible joint filler materials or joint surfaces at back of joint where such adhesion would result in sealant failure. Provide self-adhesive tape where applicable.

D. Round Backer Rod for Hot-Applied Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depths and prevent bottom-side adhesion of sealant.

E. Backer Strips for Hot-Applied Sealants: ASTM D5249; Type 2; of thickness and width required to control sealant depths, prevent bottom-side adhesion of sealant, and fill remainder of joint opening under sealant.

F. Rod back-up material and bond-breaker material shall be as recommended by joint sealant manufacturer.

## 2.6 PRIMERS

A. Primers: Product recommended by joint sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint- sealant-substrate tests and field tests.

B. Cleaners for Nonporous Surfaces: Provide nonstaining, chemical cleaners of type which are acceptable to manufacturers of sealants and sealant backing materials, which are not harmful to substrates and adjacent nonporous materials, and which do not leave oily residues or otherwise have a detrimental effect on sealant adhesion or in-service performance.

C. Masking Tape: Provide nonstaining, nonabsorbent type compatible with joint sealants and to surfaces adjacent to joints.

D. Accessory Materials for Fire-Stopping Sealants: Provide forming, joint fillers, packing and other accessory materials required for installation of fire-stopping sealants as applicable to installation conditions indicated.

## 2.7 JOINT CLEANING EQUIPMENT

A. Equipment used for cleaning the joints shall consist of, but not be limited to, the following items.

B. Concrete Saw: The concrete saw shall be a self-propelled power saw with diamond or abrasive blades designed for sawing hardened concrete without damaging the sides, bottom, or top edges. Blades may be single or gang-type with one or more blades mounted in tandem for fast cutting. All blades shall be of the proper hardness for the concrete being sawed. The saw shall be adequately powered and capable of cutting to the specified width and depth with not more than two passes of the saw through the joints.

C. Sandblasting: Sandblasting equipment shall be standard commercial type capable of effectively scaling off any foreign material which may prevent proper bond of the new sealer. The compressor used for sandblasting shall provide air at a pressure of not less than 620 kPa and a minimum volume of 4.25 cu. m per minute at the nozzle. It shall be equipped with a moisture trap that effectively trap moisture and provide relatively dry air and not preventing free flow of sand. A dial gage indicating the air pressure shall be installed in a clearly visible location. A flexible hose of the proper diameter and of sufficient length shall be an integral part of the equipment. The nozzle shall be of a diameter in proper relation to the width of the joint, and equipped with a guide that maintains the nozzle at a constant height, alignment, and angle of inclination. The guide shall be fabricated to allow adjustments in height and angle of inclination of the nozzle to secure the desired results.

D. Air Compressor: The air compressor shall be portable arid, oil free, capable of blowing out sand and other objectionable materials from the joints. This equipment shall meet the same capacity requirements as specified for the compressor for the sandblasting equipment. The compressor shall be equipped with sufficient hose of adequate capacity and nozzles of proper size for joint to be cleaned.

E. Vacuum Sweeper: The vacuum pickup sweeper shall be self-propelled and capable of completely removing all loose joint material, concrete slurry from the joints after sawing, and debris from the pavement surface. A sweeper of adequate capacity or a sufficient number of sweepers shall be provided to maintain the work area to the cleanliness standards required on airfield pavements.

## 2.8 APPLICATION EQUIPMENT FOR HOT-POURED SEALER

A. Applicators used for heating and installing the sealing materials shall be of the mobile type and equipped with a double-wall agitator-type kettle with suitable oil-type extruding device with nozzle or nozzles shaped for insertion in the joints to be filled, positive temperature devices for controlling the temperature of oil bath and sealer, and a recording thermometer for recording the temperature of

the sealer. The applicator unit shall be designed so that the sealer may be circulated in the inner kettle when not in use and capable of completely filling the joint with the sealer without formation of voids or entrapped air. The applicator wand shall be insulated all the way to the nozzle and maintained in a satisfactory working condition.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

A. General:

1. Final cleaning operations shall not proceed in advance of sealing operations by more than one working day, except as otherwise approved by the Engineer. Joints shall be thoroughly cleaned of all laitance, curing compound, dirt, and other foreign material. Cleaning procedures that cause excessive spalling along joints, as determined by the Engineer, shall not be used. Make changes in method of cleaning or equipment utilized as required to eliminate spalling. Concrete faces and the pavement surfaces extending approximately 13 mm from the joint edges shall be refaced by sandblasting. Sandblasting shall be continued until the joint surface and edges are clean and have etched surfaces. The joint shall be completely free of dust, dirt, and any other material that might prevent bonding of the sealer. After the sandblasting operation and immediately before the sealer is placed, the joints shall be thoroughly blown out by means of an air jet supplied by an air compressor meeting the requirements specified. Compressed air may be used at any time during the cleaning operations. However, to insure removal of all loose material, a jet of compressed air is required immediately ahead of pouring operations, but in no case precede pouring by more than 30 minutes. Debris pick-up and disposal shall be a continuous process during cleaning operations, and the pavement surface be thoroughly cleaned immediately prior to sealing operations with a vacuum sweeper supplemented with hand brooms and tools, as required. Dispose of debris as directed.
2. Curing tape, masking tape or other approved bond-breaker shall be installed in each joint as shown on the Drawings. Submit the bond-breaker to the Engineer for approval prior to placing any joint seal material. The bond-breaker shall be installed in the joints without being stretched or damaged.

B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint sealant manufacturer's recommendations. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.

C. Time of Application: Joint shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including construction equipment. The pavement temperature shall be above 4 deg C at the time of installation of the preformed joint seal and above 10 deg C at the time of installation of the joint seal of material.

D. Sawing Joints: Saw joints with a concrete saw to the depth and width shown within a tolerance of plus or minus 1.5 mm. After sawing, joints shall present a straight rectangular opening with vertical sides.

E. Widening Cracks by Sawing: Random cracks shall be prepared for sealing as determined by the Engineer. The top of all random cracks shall be grooved to a depth of 20 mm and a width of not less than 10 mm and not more than 15 mm by means of a rotary-cutting type grooving machine. The grooving tool shall be capable of following closely the path of the crack and of widening the top of the crack to the required section without spalling or otherwise damaging the concrete. The side walls of cracks after cutting shall be vertical.

F. Sandblast Cleaning: Concrete joint faces and the pavement surfaces extending 13 mm from the joint edges shall be sandblast cleaned. Use a multiple-pace technique until the surfaces are free of saw cutting fines that might prevent bonding of the sealant to the concrete. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of sand and water.

## 3.3 INSTALLATION OF JOINT SEALANTS

A. General:

1. Comply with joint sealant manufacturer's written installation instructions applicable to products and applications indicated, unless more stringent requirements apply.
2. No Joint sealer shall be installed until the joints to be sealed have been inspected and approved. A bondbreaker shall be installed in the bottom of all joints just prior to pouring. Pouring of the joints shall be done in a neat, workmanlike manner. The joint sealing compound shall be applied into the joints by extending the material to fill the joints uniformly solid from bottom to top.

B. Sealant Installation Standard: Comply with recommendations of ASTM C1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install backer materials of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of backer materials.
2. Do not stretch, twist, puncture, or tear backer materials.
3. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.

D. Install sealants by proven techniques to comply with the following and at the same time backings are installed:

1. Place sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses provided for each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.

1. Remove excess sealants from surfaces adjacent to joint.
2. Use tooling agents that are approved in writing by joint sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint sealant manufacturer's written instructions, unless otherwise indicated.

G. Provide recessed joint configuration for silicone sealants of recess depth and at locations indicated.

H. The joints shall be filled to 6 mm of the top of the pavement as shown, without formation of voids or entrapped air using the type of equipment specified.

I. Excess sealer or sealer that has been inadvertently spilled shall be removed from the pavement by approved methods and discarded.

J. Traffic shall not be allowed for 24 hours over pavement, except as approved. Use of gravity methods of application and pouring pots will not be allowed except as approved.

K. Hot Poured Sealants:

1. The joint sealant shall be applied solid, uniformly from bottom to top and shall be filled without formation of entrapped air or voids.
2. A backing material shall be placed as shown on the plans and shall be non-adhesive to the concrete or the sealant material.
3. The heating kettle shall be an indirect heating type, constructed as a double boiler. A positive temperature control and mechanical agitation shall be provided. The sealant shall not be heated to more than 11 deg. C below the safe heating temperature. The safe heating temperature can be obtained from the manufacturer's shipping container.
4. A direct connecting pressure type extruding device with nozzles shaped for insertion into the joint shall be provided.
5. Any sealant spilled on the surface of the pavement shall be removed immediately.
6. Backup materials and bond breakers should be compatible with the sealant, should not adhere to the sealant, should be compressible without extruding the sealant, and should recover to maintain contact with the joint faces when the joint is open.

L. Cold Applied Sealants: Cold applied joint sealing compound shall be applied by means of pressure equipment that will force the sealing material to the bottom of the joint without spilling the material on the surface of the pavement. A backing material shall be placed as shown on the plans and shall be non-adhesive to the concrete or the sealant material. Sealant which does not bond to the concrete surface of the joint walls, contains voids, or fails to set to a tack-free condition will be rejected and replaced by the Contractor at no additional cost. Before sealing the joints, the Contractor shall demonstrate that the equipment and procedures for preparing, mixing, and placing the sealant will produce a satisfactory joint seal. This shall include the preparation of two small batches and the application of the resulting material.

M. Preparation of Joint Sealing Material (Hot-Poured Sealer): Sealer shall not be heated in excess of the safe heating temperature recommended by the manufacturer as shown on sealer container. Any sealer that has been overheated or has remained in the applicator at the end of the day's operation shall be withdrawn and disposed of.

N. Weather Limitations: The concrete at the joint shall be surface dry, and the atmospheric and pavement temperature above 10 deg C at time of application of the sealing material. No sealant shall be applied in foggy or rainy weather.

O. Approval of Sealed Joints: Any joints that do not meet the requirements as determined by the Engineer shall be corrected by removing the sealer and resealing the joints in a satisfactory manner.

P. Preformed Elastomeric Joint Seals:

1. Preformed joint sealer shall be placed using equipment capable of installing the sealer in the upright position, without cutting, nicking, distorting, or otherwise damaging the seal.
2. Lubricant shall be applied to the concrete or the preformed seal, or both, and the seal shall be installed in a substantially compressed condition and at the depth below the surface of the pavement as shown in the plans.
3. The method of installation shall be such that the joint sealer will not be stretched more than 5 percent of the minimum theoretical length, or compressed more than 2 percent.
4. The method of installation shall be checked for stretching or compression, using transverse joint sealer. The check shall consist of installing sealer in five joints of at least 7.5 m in

length, removing the sealer immediately after installation, and checking the length. This check may be modified by premarking or precutting the sealer to length prior to installation if this is compatible with the equipment being used.

5. If the measured length of any of these five sealers indicated that the sealer is stretched or compressed beyond these limits, the installation shall be modified to correct the situation.
6. Once satisfactory sealing operations have started, one joint length per every hundred shall be removed and checked.
7. If the limits are exceeded, the joint sealers on either side should be removed until the condition disappears. The affected joints shall be resealed in a satisfactory manner at own cost, and the method of installation shall be checked again for satisfactory procedure.
8. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections for continuous installation of the seal in the transverse joints.

## 3.4 TRIAL JOINT INSTALLATION

A. Preliminary to sealing of joints for the entire project, a length of at least 50 m of joint in an approved location shall be cleaned and prepared, and the joint filled with sealant material in the manner proposed for completion of the entire Project. This section shall be inspected prior to continuing work to determine that the installation satisfactorily meets all requirements. If the trial installation is not satisfactory, the material shall be removed and an additional 50-m length of joint shall be cleaned, prepared, filled and inspected. Following approval of a trial installation, all other joint grooves shall be cleaned, prepared and filled in a similar manner, subject to the approval of the Engineer.

## 3.5 CLEANING

A. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

## 3.6 PROTECTION

A. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Taking Over. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from the original work.

## 3.7 PAVEMENT-JOINT-SEALANT SCHEDULE

A. Joint-Sealant Application: Joints within cement concrete pavement.

1. Joint Location:

    a. Expansion and isolation joints in cast-in-place concrete pavement.
    b. Contraction joints in cast-in-place concrete slabs.
    c. Other joints as indicated.

2. Silicone Joint Sealant for Concrete: Single component, non-sag or Single component, self-leveling , as approved by the Engineer.
3. Urethane Joint Sealant for Concrete: Multi-component, pourable, traffic-grade, as approved by the Engineer.
4. Hot-Applied Joint Sealant for Concrete: Single component, as approved by the Engineer.
5. Joint-Sealant Color: As indicated by manufacturer's designations and Match Engineer's sample, as approved by the Engineer.

B. Joint-Sealant Application: Joints between cement concrete and asphalt pavement.

1. Joint Location:

   a. Joints between concrete and asphalt pavement.
   b. Joints between concrete curbs and asphalt pavement.
   c. Other joints as indicated.

2. Hot-Applied Joint Sealant for Concrete and Asphalt: Single component, as approved by the Engineer.
3. Joint-Sealant Color: As indicated by manufacturer's designations and Match Engineer's sample, as approved by the Engineer.

END OF SECTION 609

# SECTION 610 - PAVEMENT DEMOLISHING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and the Project Requirements, apply to this Section.

### 1.2 SUMMARY

A. Section Includes:

1. Removal, wholly or in part, and satisfactory disposal of existing flexible pavement in the designated areas shown on the Drawings. It shall also include the salvaging of designated materials and backfilling the resulting holes where and as instructed by the Engineer.
2. The Contractor shall examine the Site and carry out a precondition survey to record all obstructions and utilities and site inventory at the commencement of the Works and prior to demolishing or milling off.

B. Related Sections:

1. Section 605 “Asphalt”
2. Section 600 “Site Clearing”

### 1.3 DEFINITIONS

A. Remove: Detach items from existing construction and legally dispose of them off-site unless indicated or directed to be removed and salvaged or removed and re-used.

B. Remove and Salvage: Carefully detach from existing construction, in a manner to prevent damage, and store for reuse.

C. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and re-used.

### 1.4 PREINSTALLATION MEETINGS

A. Pre-demolition Conference: Conduct conference at Project site to comply with the Project Requirements. Review methods and procedures related to pavement demolition including, but not limited to, the following:

1. Inspect and discuss condition of construction to be demolished.
2. Review and establish extent of any 'restricted' areas of demolition.
3. Review and finalize pavement demolition schedule and verify availability of demolition personnel, equipment, and facilities needed to make progress and avoid delays.
4. Review and finalize protection requirements.
5. Review procedures for noise control and dust control.
6. Review procedures for protection of adjacent structures.
7. Discuss existing utilities and subsurface conditions
8. Review coordination with temporary controls and protections.

9. Review items to be salvaged and returned to Employer.

1.5 ACTION SUBMITTALS

A. Existing Conditions: Documentation of existing adjoining construction, services, utilities and fuel lines, pavement and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by demolishing works.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions, to ensure that the existing services are kept in a safe and stable condition for the duration of the Works.

C. Structures and installations to be demolished shall be surveyed by the Contractor and sketches of these structures and installations shall be submitted to the Engineer, to establish exposed constructional dimensions and details. This information shall be used by the Engineer to confirm the scope of the demolition and the materials or equipment to be recovered.

D. The Contractor shall submit to the Engineer's approval the method of pavement demolition works including the sequence of operations and any special procedural requirements not less than seven days from the start of the execution works.

1.6 INFORMATIONAL SUBMITTALS

A. Engineering Survey: Submit engineering survey of condition of existing pavement, as directed by the Engineer.

B. Schedule of Pavement Demolition Activities: Indicate the following:

1. Detailed sequence of demolition and removal work, with starting and ending dates for each activity.
2. Permanent or temporary interruption of utility services.
3. Coordination for shutoff, capping, re-routing and continuation of utility services.
4. Coordination of Employer's continuing on-site operations, including occupancy or partial use of premises, if any.

C. Pre-demolition Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by pavement demolition operations. Submit before works begins.

D. Survey for existing pavement: submit a survey for existing pavement to be demolished in case As- Built drawings are not available.

E. Submit No Objection Certificates "NOC" from all end-users, concerned authorities and utility providers prior to proceed with demolition works.

F. Submit method statement, Work Notification to the Engineer's review and approval.

1.7 CLOSEOUT SUBMITTALS

A. Inventory: After pavement demolition is complete, submit lists of items that have been removed and salvaged or removed for re-use.

1.8 QUALITY ASSURANCE

A. Equipment shall demonstrate compliance with the Project Requirements.

B. Preinstallation Conference: Conduct conference at Project site prior to commencing pavement demolishing operations.

C. Demolition Firm Qualifications: An experienced firm that is specialized in demolition work similar in material and extent to that indicated for this Project.

D. Professional Engineer Qualifications: A professional engineer who is legally registered and qualified to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated.

E. Regulatory Requirements: Before beginning demolition, comply with notification regulations of authorities having jurisdiction. Comply with hauling, including means and methods of transport, and disposal regulations of authorities having jurisdiction.

1.9 FIELD/PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining road facilities, and other adjacent occupied or used facilities during demolishing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Engineer and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by the Engineer or authorities having jurisdiction.

B. Protection of Existing Improvements: Provide protections necessary to prevent damage to existing improvements indicated or directed to remain in place. Restore damaged improvements to their original condition, to the satisfaction of the Engineer.

C. A No objection certificate (N.O.C) shall be obtained from the concerned authorities prior to the start of any demolishing works.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.1 MATERIAL OWNERSHIP

A. Except for materials indicated or directed to be stockpiled or otherwise remain the Employer’s property, demolished materials shall become the Contractor's property and shall be removed from Project site.

3.2 GENERAL

A. The Contractor’s removal operation shall be controlled to not damage adjacent pavement structure, and base material, cables, utility ducts, pipelines, or drainage structures which are to remain under the pavement.

B. The Contractor shall raze, remove and dispose off old pavement of different types to depths as indicated on the drawings, for the portions which are within the Limit of Work. All

designated material shall be removed, without causing unnecessary damage.

C. Unusable perishable material shall be disposed of in accordance with the applicable laws and regulations. Non-perishable material may be disposed of off the Site, provided permission of the respective property owners has been obtained in writing to dump such materials on their land.

D. Cavities left by pavement removal shall be filled to the level of the surrounding ground and, if within the prism of construction, shall be compacted as specified for Subgrade Construction under Section 321000.

## 3.3 REMOVAL OF LIGHTING EQUIPMENT

A. The Contractor shall remove the airfield lighting equipment (fixtures, accessories and the like) before removal of the existing pavements layers.

## 3.4 PROTECTION OF EXISTING UTILITIES

A. The Contractor shall be responsible for supporting and protecting existing Utilities that are to remain in place, for the duration of the Contract and shall provide all necessary Temporary Works in this respect. Any damage caused to Utilities and attributable to the Contractor shall be repaired at his expense.

B. The Contractor shall be responsible for and shall ensure that pavement removal operations must be completed without applying extreme vibration and heavy loading that may damage the existing underground utilities.

## 3.5 STOCKPILING PAVEMENT DEMOLISHED MATERIAL

A. During the recovery and stockpiling operations, asphalt pavement containing soil or other debris shall be kept separate from recovered pavement which does not contain soil or other debris.

B. Existing pavement to be recovered shall be removed and stockpiled by methods which will minimize losses and prevent it being contaminated with other materials. The Contractor shall ensure that the stockpiled material is relatively free of soil and other matter.

## 3.6 CLEANING

A. Clean adjacent structures and improvements of dust, dirt, and debris caused by pavement demolition operations. Return adjacent areas to condition existing before pavement demolition operations began.

1. Clean nearby areas and pavements of debris caused by debris transport.

END OF SECTION 610

# SECTION 312319 - DEWATERING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including Conditions of Contract and Division 01 Specification Sections, apply to this Section.

### 1.2 SUMMARY

A. Section includes construction dewatering.

B. Related Sections:

1. Section 013200 "Construction Progress Documentation" and "Photographic Documentation" for recording preexisting conditions and dewatering system progress.
2. Section 312000 "Earth Moving" for excavating, backfilling, site grading, and for site utilities.
3. Section 315000 "Excavation Support and Protection" for shoring, bracing, and sheet piling of excavations.
4. Section 334600 "Subdrainage" for permanent foundation wall, underfloor, and footing drainage.

### 1.3 PERFORMANCE REQUIREMENTS

A. Dewatering Performance: Design, furnish, install, test, operate, monitor, and maintain dewatering system of sufficient scope, size, and capacity to control hydrostatic pressures and to lower, control, remove, and dispose of ground water and permit excavation and construction to proceed on dry, stable subgrades.

1. Delegated Design: Design dewatering system, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
2. Continuously monitor the drawdown water level to ensure ground water table is sufficiently lowered below the bottom of excavation level.
3. Maintain dewatering operations to ensure erosion control, stability of excavations and constructed slopes, that excavation does not flood, and that damage to subgrades and permanent structures is prevented.
4. Prevent surface water from entering excavations by grading, dikes, or other means.
5. Undertake all necessary temporary works to accomplish dewatering without damaging existing buildings, structures, and site improvements adjacent to excavation.
6. Remove dewatering system when no longer required for construction.
7. The contractor should carryout aquifer test to determine the hydrogeology of the existing substrata as instructed by the Engineer.
8. Seepage into the excavation which allows migration of soil particles shall not be allowed. Immediate correction of the operations shall be made if loss of ground results from seepage, such that further loss of ground is prevented and the original state of ground is reinstated.

## 1.4 SUBMITTALS

A. Shop Drawings: For dewatering system. Show arrangement, locations, and details of wells and well points; locations of risers, headers, filters, pumps, power units, and discharge lines; and means of discharge, control of sediment, and disposal of water.

1. Include layouts of piezometers and flow-measuring devices for monitoring performance of dewatering system and checks on erosion.
2. Include a written plan for dewatering operations including control procedures to be adopted if dewatering problems arise.
3. Full detailed Method statement should be submitted prior to commencement; the method statement should be approved by the engineer.

B. Method Statement: Provide a detailed narrative describing means, methods and techniques to be adopted for the dewatering system. The Method Statement shall include, but not be limited to, the following:
1. Control procedures to be adopted,
2. Verification of the sediment load in the discharge water,
3. Details of the pipe network and pumps to collect the discharge water,
4. A scheme of contingency measures in case of dewatering system breakdown,

C. Delegated-Design Submittal: For dewatering system indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

D. Qualification Data: For qualified Installer, land surveyor and professional engineer.

E. Field quality-control reports..

F. Other Informational Submittals:

1. Photographs or Videos: Show existing conditions of adjoining construction and site improvements that might be misconstrued as damage caused by dewatering operations.

## 1.5 QUALITY ASSURANCE

A. Installer Qualifications: An experienced installer that has specialized in design of dewatering systems and dewatering work.

B. Regulatory Requirements: Comply with governing EPA notification regulations before beginning dewatering. Comply with hauling and disposal regulations of authorities having jurisdiction.

C. Preinstallation Conference: Conduct conference at project location.

1. Review methods and procedures related to dewatering including, but not limited to, the following:

a. Inspection and discussion of condition of site to be dewatered including coordination with temporary erosion control measures and temporary controls and protections.
b. Geotechnical report.
c. Proposed site clearing and excavations.
d. Existing utilities and subsurface conditions.
e. Coordination for interruption, shutoff, capping, and continuation of utility services.
f. Construction schedule. Verify availability of Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
g. Testing and monitoring of dewatering system.

h. Safety requirements.

1.6 PROJECT CONDITIONS

A. Interruption of Existing Utilities: Do not interrupt any utility serving facilities on the Project site or on adjoining properties unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Notify the Engineer no fewer than two days in advance of proposed interruption of utility.
2. Do not proceed with interruption of utility without Engineer's written permission.

B. Project-Site Information: A geotechnical report has been prepared for this Project and is available for information only. The opinions expressed in this report are those of geotechnical engineer and represent interpretations of subsoil conditions, tests, and results of analyses conducted by geotechnical engineer. The Employer will not be responsible for interpretations or conclusions drawn from this data.

1. Make additional test borings and conduct other exploratory operations necessary for dewatering.
2. The geotechnical report is included elsewhere in the Project Manual.
3. The contractor should carryout aquifer test to determine the hydrogeologic parameters of the existing substrata.

C. Survey Work: Engage a qualified land surveyor or professional engineer to survey adjacent existing buildings, structures, and site improvements, establishing exact elevations at fixed points to act as benchmarks. Clearly identify benchmarks and record existing elevations.

1. During dewatering, regularly resurvey benchmarks, maintaining an accurate log of surveyed elevations for comparison with original elevations. Promptly notify the Engineer if changes in elevations occur or if cracks, sags, or other damage is evident in adjacent construction.

PART 2 - PRODUCTS

(Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities on or adjacent to the site from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by dewatering operations.

1. Prevent surface water and subsurface or ground water from entering excavations, from ponding on prepared subgrades, and from flooding site and surrounding area.
2. Protect subgrades and foundation soils from softening and damage by rain or water accumulation.

B. Install dewatering system to ensure minimum interference with roads, streets, walks, and other adjacent occupied and used facilities.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from the Engineer and authorities having jurisdiction.

2. Provide alternate routes around closed or obstructed traffic ways if required by the Engineer or authorities having jurisdiction.

C. Provide temporary grading to facilitate dewatering and control of surface water.

D. Monitor dewatering systems continuously.

E. Promptly repair damages to adjacent facilities caused by dewatering.

F. Protect and maintain temporary erosion and sedimentation controls, which are specified in Section 015000 "Temporary Facilities and Controls" during dewatering operations.

## 3.2 INSTALLATION

A. Install dewatering system utilizing wells, well points, or similar methods complete with pump equipment, standby power and pumps, filter material gradation, valves, appurtenances, water disposal, and surface-water controls.

1. Space well points or wells at intervals required to provide sufficient dewatering.
2. Use filters or other means to prevent pumping of fine sands or silts from the subsurface.

B. Before excavating below ground-water level, place dewatering system into operation to lower and maintain water to specified levels. Operate system continuously until drains, sewers, fill and structures have been constructed and until written authorization to cease dewatering is received from the Engineer.

C. Provide an adequate system to lower and control ground water to permit excavation, construction of structures, and placement of fill materials on dry subgrades. Install sufficient dewatering equipment to drain water-bearing strata above and below bottom of foundations, drains, sewers, and other excavations.

1. Do not permit open-sump pumping that leads to loss of fines, soil piping, subgrade softening, and slope instability.

D. Reduce hydrostatic head in water-bearing strata below subgrade elevations of foundations, drains, sewers, and other excavations.

1. Maintain piezometric water level a minimum of 500 mm below surface of excavation.

E. Dispose of water removed by dewatering in a manner that avoids endangering public health, property, and portions of work under construction or completed. Dispose of water and sediment in a manner that avoids inconvenience to others. Provide sumps, sedimentation tanks, and other flow-control devices as required by authorities having jurisdiction.

F. Provide standby equipment on site, installed and available for immediate operation, to maintain dewatering on continuous basis in the event that any part of system becomes inadequate or fails. If dewatering requirements are not satisfied due to inadequacy or failure of dewatering system, restore damaged structures and foundation soils at no additional expense to the Employer.

1. Remove dewatering system from Project site on completion of dewatering. Plug or fill well holes with sand or other approved material or cut off and cap wells a minimum of 900 mm below overlying construction.

G. Damages: Promptly repair and restore to original condition any damages to adjacent structures, utilities, sidewalks, pavements and other facilities caused by dewatering operations.

## 3.3 FIELD QUALITY CONTROL

A. Observation Wells: Provide, take measurements, and maintain at least the minimum number of observation wells or piezometers indicated; additional observation wells may be required by the Engineer or authorities having jurisdiction.

1. Observe, record and report to the Engineer daily elevation of ground water and piezometric water levels in observation wells.
2. Repair or replace, within 24 hours, observation wells that become inactive, damaged, or destroyed. Suspend construction activities in areas where observation wells are not functioning properly until reliable observations can be made. Add or remove water from observation-well risers to demonstrate that observation wells are functioning properly.
3. Fill observation wells, remove piezometers, and fill holes when dewatering is completed.

B. Provide continual observation to ensure that subsurface soils are not being removed by the dewatering operation.

C. Maintain and continuously operate the dewatering system without any interruption.

END OF SECTION 312319

# SECTION 612 - GEOTECHNICAL INVESTIGATIONS

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. “Drawings and general provisions of the Contract, including General and Particular Conditions, Procedures, Manuals and Specifications, apply to this Section”.

### 1.2 SUMMARY

A. Section Includes:

1. The general requirements and information for the execution of geotechnical investigations. Nevertheless, it does not substitute referenced standards.
2. The local Laws, Standards and Regulations take precedence over the specifications herein and any other referenced code. The Contractor shall remain responsible for complying with all applicable and latest local laws, regulations, building codes, standards and guidelines.
3. Notwithstanding this specification, the selection of methods and techniques shall be governed by experience and sound judgment as dictated by the soil type and subsurface conditions. Extreme care in the application of geotechnical investigation methods is demanded for obtaining reliable results.
4. The Contractor is responsible for the competency of the methods used, for abiding by the Standards, and for the accuracy of the observations, descriptions and reports.
5. It is the responsibility of the Contractor to establish appropriate safety and health practices, to address all of the regulatory and safety requirements and to determine the applicability of regulatory limitations.

B. Codes and Standards:

1. The Contractor shall comply with provisions of the latest issue of the following standards, codes, guides and manuals except where advised otherwise by the Engineer:

    a. ASTM Standard Practices & Guides:

        1) D420: Site Characterization for Engineering, Design, and Construction Purposes.
        2) D1452: Standard Practice for Soil Exploration and Sampling by Auger Borings.
        3) D1586: Standard Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils.
        4) D1587: Standard Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes.
        5) D2113: Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration.
        6) D2488: Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).
        7) D3550: Standard Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils.
        8) D4220: Standard Practices for Preserving and Transporting Soil Samples.
        9) D2113 Standard Practice for Rock Core Drilling and Sampling of Rock for Site Exploration.
        10) D5434: Standard Guide for Field Logging of Subsurface Explorations of Soil and Rock.

11) D5782: Standard Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.
12) D5783: Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices.
13) D5875: Standard Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices.
14) D5876: Standard Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices.
15) D6151: Standard Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling.
16) D6169: Standard Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations.
17) D6282: Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations.
18) D6286: Standard Guide for Selection of Drilling and Direct Push Methods for Geotechnical and Environmental Subsurface Site Characterization.
19) D6519: Standard Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler.
20) D6640: Standard Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations.
21) D6907: Standard Practice for Sampling Soils and Contaminated Media with Hand- Operated Bucket Augers.

b. BS EN 1997 Part 2- Geotechnical Design Part 2 Ground Investigation and Testing.
c. BS 5930 Code of Practice for Site Investigations.
d. EM 1110-1-1804: Geotechnical Investigations-USACE Engineer Manual
e. Earth Manual.
f. ISRM publications.

2. If an applicable reference document is not listed in the specification, the Contractor shall inform the Engineer on the standards or methods he intends to use and obtain approval.
3. If two or more standards are specified and establish different or conflicting provisions for quantitative or qualitative requirements, the Contractor shall comply with the most stringent requirement and refer uncertainties or requirements that are different, for agreement with the Engineer before proceeding.

## 1.3 ACTION SUBMITTALS

A. Prior to start of works, Contractor shall submit for approval of Engineer the following documents in compliance with local regulations:

1. Project Execution Plan and method statements,
2. Health, Safety and Environmental Management Plan,
3. Project Quality Plan,
4. Heat Stress Plan,
5. Job Hazard Analysis,
6. Emergency Response Plan.

B. Program of Work:

1. The Contractor shall prepare a program of works for the geotechnical investigation in the form of a Gant chart that shows the proposed time schedule of all activities of the investigation and subsequent submittals.

C. Method Statements:

1. The Contractor shall provide a description of the envisaged works in method statements. These shall be submitted for approval by the Engineer prior to any start of work.
2. The method statement shall cover all relevant aspects of the works and includes, but is not limited to, details of all work procedures; plant, equipment and personnel; HSE; sketches; reporting, etc.

D. Daily Reports:

1. The Contractor shall produce a daily written record/report of his operations. Information shall be recorded as work proceeds. A copy of the Contractor's daily record shall be forwarded to the Engineer within 24 hours of the work to which it refers having been undertaken.
2. Daily report information shall be submitted in electronic form, either in Microsoft Excel, Word, Portable Document Format (.pdf), or other equivalent digital formats approved by the Engineer. Photographs shall be supplied in .jpeg or similar file formats.
3. Information for inclusion in the Sub-Contractor's daily progress report shall include, but shall not be limited to:

    a. Contract title and site location
    b. Day and date
    c. Weather Conditions
    d. Photographs of the site, and a plan showing the location and orientation of photos
    e. Details of the personnel, plant, equipment and materials on site.
    f. Summary of operations executed with times and durations.
    g. Type and depth of any utilities/ obstructions encountered
    h. Type of drilling fluid.
    i. Water level readings in previously installed standpipes or standpipe piezometers
    j. The types of samples, method of sampling, retrieval depth, and length of undisturbed or core sub samples recovered;
    k. Excavation details of trial pits, method of support and comments on stability
    l. The depths and details of all in-situ tests
    m. Details of backfilling operations
    n. Presence of problematic soils/ cavities
    o. Progress against Program of Work.

E. Logs:

1. All pertinent borehole, test pit and sampling data must be recorded in a log. Clear and accurate data are required to describe the soil profile and sample locations. Information and observations which may aid in estimating the condition of the samples and the physical properties of the in-situ soil shall be recorded.
2. The Contractor shall prepare for each borehole or test pit an initial log (including in-situ test results) which shall be submitted to the Engineer within 24 hours of the completion of the borehole/test pit.
3. The following information shall be included on the initial logs of each borehole:

    a. Borehole/Test pit number or designation, surveyed coordinates and top elevation.
    b. Driller's name and Geologist's name.
    c. Make, size, and manufacturer's model designation of drilling and sampling equipment.
    d. Type of drilling, sampling, and testing operation by depth.
    e. Hole diameter/ In-plan dimensions of the pit.
    f. Time required for drilling each run.
    g. Drill action, rotation speed, hydraulic pressure, water pressure, tool drops, and any other unusual and non-ordinary experience which could indicate the subsurface conditions encountered.
    h. Depths at which samples or cores were recovered.

i. Classification or description by depths of the materials retrieved.
j. Classification and description by depths of rock materials including rock type, composition, texture, presence and orientation of bedding, foliation, or fractures, presence of vugs or other interstices, Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD), Fracture Index for each cored interval.
k. Indication of penetration resistance in terms of blow count.
l. Force Weight of drive hammer.
m. Percentage of sample or core recovered per run.
n. Depth at which groundwater is encountered initially and when stabilized.
o. Depths at which drill water is lost and regained and amounts.
p. Depths at which the color of the drill water return changes.
q. Type and weight of drill fluid.
r. Depth of bottom of hole.

4. After completion of all soil tests and visual examination of all samples in the laboratory, prepare final logs including grid or topographical reference and details corrected by a qualified soil Engineer or engineering Geologist in light of all information finally available.

F. Schedule of Laboratory Testing:

1. Schedule and type of laboratory testing shall be submitted to the Engineer for approval for each borehole within 48 hours, after completion of the borehole.
2. Schedule of laboratory testing shall be oriented towards obtaining data pertinent to the purpose of the work and based on type and conditions of retrieved samples.

G. Preliminary Test Results:

1. Laboratory test results shall be submitted to the Engineer in batches at the completion of each week's testing.
2. Draft in-situ test results shall be submitted to the Engineer in each daily report.

H. Final Report:

1. The final report shall comprise factual and interpretative parts as required by the Engineer.
2. The factual part shall contain, as a minimum, the following information:

a. A statement on the purpose and reasons for the investigation.
b. A description of the work carried out, including reference to specification and standards adopted and any deviations from them.
c. Exploratory hole logs.
d. In-situ test records.
e. Laboratory test results.
f. Plots of all laboratory and in situ test results against depth
g. Plan with locations of exploratory holes.
h. Plan showing surface deposits / rock outcrops, fill, geologic features (Engineering Geological map);
i. Geological cross-sections
j. Independently bound appendix of color photographs of all rock cores, test pits and trenches and any other features relevant to the text and observations

3. The interpretative part shall contain the following information:

a. A written appraisal of the ground and water conditions.
b. Analysis and recommendations as designated.
c. When so designated, the Contractor shall supply the calculations and analyses on which recommendations are based.

4. The report and its contents shall be submitted in electronic form:

    a. The Report shall be provided in Microsoft Word and in Portable Document Format (.pdf)
    b. Laboratory test sheets and summary of test results shall be submitted in Microsoft Excel.
    c. In situ test sheets shall be submitted in Microsoft Excel.
    d. Photographs shall be supplied in .jpeg or similar file formats.
    e. Layout Drawings and Geologic Sections shall be provided in AutoCAD.

5. Approval of Report:

    a. Two (2) copies of the draft report shall be submitted to the Engineer for approval at least six (6) days before the end of the Contract Period. The Engineer shall inform the Contractor of any corrections or amendments within three (3) days of receipt of the draft.
    b. Four (4) bound copies and one (1) unbound copy of the accepted report in English, shall be produced in A4 size.

I. Digital Data:

1. Data Format:

    a. The format of the digital data files shall be as set out in the latest version of the AGS publication Electronic Transfer of Geotechnical and Geo-environmental Data or as published on the AGS website (http://www.ags.org.uk/site/home/index.cfm), whichever is more recent.
    b. Digital data shall be provided in American Standard Code for Information Exchange 'ASCII' format. Data shall be supplied on a data storage media as agreed with the Engineer and shall be compatible with Microsoft operating systems. The files shall not be compressed.

2. Checking of Data:

    a. The Contractor shall check that digital data to be submitted conforms to all AGS formatting and other requirements, before issue. The data shall be run through a format checking program compatible with the version of AGS data being used, before being issued. Any discrepancies in formatting or other data issues resulting in the Engineer having difficulties in processing the supplied data are unacceptable, and the Contractor shall remain wholly responsible for the timely correction of any anomalies to the total satisfaction of the Engineer. Any corrections shall be entirely at the Contractor's expense.

3. Data Transfer:

    a. All issues of digital data from the Contractor to the Engineer shall be accompanied by a unique transmittal sheet and index detailing the precise nature of the data issued.
    b. Data disks in each issue, together with any protective casing, shall be securely labelled and clearly marked with the following information:

        1) The project identification (PROJ-ID).
        2) The name of the -Contractor.
        3) The title 'AGS Format ASCII Data'.
        4) The AGS Edition number.
        5) A unique alpha-numeric dataset identifier.
        6) The name of the Project Manager; and
        7) The date of issue to the Project Manager.

c. The necessity of splitting the digital data into separate files shall be determined by the Contractor. Unique alpha-numeric data referenced identifiers shall be adopted for each portion of data and these shall run sequentially from the start of the Project. The Contractor shall maintain an index detailing for each issue of data:

1) The project identification (PROJ-ID).
2) The name of the Contractor.
3) The title 'Media Index Record'.
4) The title 'AGS Format ASCII Data'.
5) The AGS Edition number.
6) A unique alpha-numeric dataset identifier.
7) The name of the Project Manager's Representative to whom the data was given;
8) The data of issue to the Engineer; and
9) A general description of the data transferred and/or a file listing for associated files.
10) In addition, the index shall provide for each data set, including all associated files:
11) The file name, including the extension.
12) The date and time the file was created.
13) The file size in bytes; and,
14) A general description of the data contained in each file and/or a file listing for associated files.

d. Data files shall be checked for computer viruses before issue using a proprietary antivirus program. An identical copy of each set of data issued to the Engineer and of the transmittal sheet and index for each issue shall be retained by the Contractor until the end of the maintenance period.

4. Preliminary Data:

a. Where required in the Specification or when requested by the Engineer, the Contractor shall issue preliminary digital data to correspond with the preliminary paper records. In addition to the labelling required above, preliminary disks shall be labelled "PRELIM". All preliminary digital data shall be presented in the same format as the final digital data to be provided with the approved final Report and must be produced from the same source/program as that which will be used to produce the final Report.
b. Preliminary digital data shall be updated as necessary (as for paper records) in the light of laboratory test results and further examination of samples and cores.

5. Digital Data Issued with the Final Report:

a. Digital data as specified shall be presented with the draft and final Reports. The Report shall clearly indicate where data are included as a paper record, but are not included in digital format.
b. The disk(s) or other agreed transmission media shall be contained within the covers of the Report in such a manner that they are secure within the documents but permit ready access.
c. The digital data provided with the draft Report shall be complete and a total replacement of any previous issue of digital data. The digital data provided with the approved final Report shall be labelled 'FINAL'.

6. Units of Measurement for AGS Data Transfer:

a. The units of measurement shall be those given in the AGS publication Electronic Transfer of Geotechnical and Geo-environmental Data or as published on the AGS website, whichever is the more recent, unless other units of measurement for digital data are required by the Contract. The units of measurement must be given in the

AGS Format files and must be the same as those used in the paper version of the report.

## 1.4 QUALITY ASSURANCE

A. "[**Product**][**Material**][**Equipment**] shall demonstrate compliance with requirements specified in Section 016000 "Product Requirements".

B. The work shall be carried out in accordance with the relevant Codes and Standards listed above.

C. Work shall be carried out in accordance with a quality management system similar to ISO 9001 and approved by Engineer prior to commencement of the works. Records to indicate compliance with quality management shall be made available to Engineer on request.

D. The Contractor shall provide full time professional attendance on site. The professional attendant shall be approved by the Engineer, and shall be responsible for the technical direction of all fieldwork. The Contractor shall provide curriculum vitae of his technical staff in his method statement.

E. The Contractor's personnel employed on the Project shall be competent to undertake the work required. All members of the crew shall be familiar with the exploration methods specified:

1. The Contractor shall provide the full-time services of a competent Engineer/Supervisor who is fluent in English, has a minimum of 10 years' experience in comparable ground investigation work and who has the authority of the Contractor to make decisions on site. The duties of the Supervisor shall include, but shall not be limited to:

    a. Attendance at site meetings prior to and during the course of works when so required by the Engineer.
    b. Liaison with the Engineer during the progress of works.
    c. Selecting and arranging for the correct equipment/personnel to be on site for the effective completion of the works and ensuring that progress of the investigation is maintained to the satisfaction of the Engineer.
    d. Preparing and submitting a Program of Work when required by the Engineer.
    e. Being responsible for the day to day operation of all plant and equipment.

2. The Contractor shall provide full time control of the investigations by a Geotechnical Engineer/ Engineering Geologist with at least 10 years relevant experience. The duties of the Geotechnical Engineer shall include, but shall not be limited to:

    a. Logging of soil and rock samples in accordance with Standards.
    b. Supervision including verification of recorded depth.
    c. Requesting additional sampling or testing if necessary to obtain complete data.
    d. Preparation of preliminary boring logs, preliminary descriptions of subsurface conditions, and lists of all samples carried to the laboratory and results of in situ tests.

3. The Contractor shall provide sufficient additional field personnel/technicians as well as clerical and administrative staff to assist him in the testing requirements and the production of preliminary records/ reports within the times specified in the contract. Field personnel/technicians shall have at least 2 years' relevant work experience including the preparation of records in English.

F. All professional and technical staff involved in the project shall be to the Engineer's consent. The Engineer reserves the right to withdraw consent at any stage during the Contract Period. If such consent shall be withdrawn by the Engineer, the Contractor shall as soon as practicable, but not later than 5 working days after receiving written notice of such withdrawal, remove such personnel from the project and shall not thereafter employ them again on the project in any capacity. At the same time, the Contractor shall replace any removed personnel by others agreed by the Engineer.

G. The Supervisor and Geotechnical Engineer must be able to receive at all times urgent instructions from the Engineer. The Contractor shall provide sufficient means to allow such urgent communication to be possible.

1.5 FIELD/PROJECTCONDITIONS

A. System of Units:

1. All dimensional data and results presented shall be expressed in SI (metric) units.

B. Geodetic Parameters:

1. All levels shall be defined by reference to <**insert reference**> Datum
2. The coordinate system shall be WGS 84.

C. Permits and Authorizations:

1. The Contractor shall be responsible for coordinating and obtaining all the necessary permits, approvals, No Objection Certificates (NOCs) from all the relevant Statutory Authorities having jurisdiction over the project.

D. Mobilization:

1. The Contractor shall mobilize all personnel, equipment and materials, supplies, consumables, services, and temporary facilities of whatsoever nature and without limitation, necessary for the safe and proper performance of the work and its timely completion.

E. Demobilization:

1. The Contractor shall demobilize all resources of whatsoever nature brought to the site including, but not limited to, personnel, equipment and materials and temporary facilities upon completion works and reinstate site to previous conditions or to a state approved by the Engineer.
2. The Contractor shall not demobilize any of the resources without prior approval of the Engineer. Such approval shall be granted provided the applicable works have been completed.

F. Temporary Facilities:

1. The Contractor shall provide and maintain all temporary facilities necessary for the safe, proper and timely performance of the work.
2. Facilities shall be provided for the use of the Engineer.
3. The Contractor shall ensure that all temporary facilities are supplied and maintained in good condition and managed all in conformity with the applicable laws and regulations.

G. Access Routes:

1. The Contractor is responsible for checking the accessibility of the site and load bearing capacity of the access roads and subsoil for the use of his proposed vehicles and equipment.
2. The Contractor shall liaise with all relevant authorities regarding permits, authorizations, timing, notifications and any necessary signs, diversions etc. required for the conduct of the investigation.

H. Traffic Diversion:

1. If deemed necessary, the Contractor shall liaise with relevant Authorities for a diversion of traffic needed for execution of works. Traffic safety and management measures shall be provided.

I. Inspection of Utilities:

1. The Contractor shall make his own enquiries as to the presence and location of any buried services, pipelines and cables, etc. Where the presence of underground services is suspected near an exploratory hole the Contractor shall ascertain that by carefully excavating an inspection pit.
2. In case of damage to existing utilities, it will be the responsibility of the Contractor to contact service providers and agree on the mitigation measures. The associated costs shall be borne by the Contractor.

J. Surveying and Setting-out:

1. The Contractor shall be responsible for setting out the locations of the exploratory holes and ensuring that they are positioned according to the Drawings and Schedules unless alternative positions have been agreed with Engineer.
2. The Engineer, upon examination of borehole logs, may request changes in number, location and depth of boreholes. The Contractor will not be entitled to modify his unit prices as a result of such changes.

K. Working Hours:

1. Working hours shall be restricted to those specified (if any) by Engineer and/or the relevant Authorities.
2. The Contractor shall be responsible for consulting with the relevant Authorities and third parties to determine working hours which he may implement at the site and to obtain necessary permits required for the execution of the works. The Contractor shall make full allowance in his Program of Works for any time restrictions required by Authorities or third parties. Any time restrictions shall be reflected in the Contractor's method statement and Program of Works.

L. Working Areas:

1. Operations shall be confined to the minimum area of ground required for performing the Works.
2. After completion of works, the Contractor shall remove all plant and equipment and shall remove all rubbish, debris and surplus material from the site. The Contractor shall be liable for any damage caused by his activities during the ground investigation and shall make good any damage at his own expense to the satisfaction of Engineer:

    a. All barriers breached or otherwise disturbed during the execution of site operations shall be immediately repaired or replaced to the same standard.
    b. Turf and topsoil shall be stripped from the site of each exploration and stockpiled for future replacement. Vegetation and topsoil adjacent to the exploration which may be damaged by the operations shall either be removed and stockpiled as above, or otherwise protected from damage. After completion of the exploration all topsoil shall be replaced and the Site restored to its original condition.
    c. Disturbed subgrades shall be properly compacted and paved surfaces restored to original conditions/ to quality and thicknesses dictated by local regulations.
3. In executing the project works, the Contractor shall make adequate arrangements for the disposal of all refuse and take any necessary precautions to prevent pollution, contamination of the water supply and injury to fish, bird and plant, or other life.
4. No spillages of dangerous, deleterious or contaminated material shall be allowed on the site.

M. Health and Safety:

1. The Contractor has full responsibility for the management of Health & Safety of the work, and shall provide necessary personal protective equipment (PPE) to all his employees and undertake all necessary measures to ensure that a safe and healthy workplace and working environment are established and maintained at all times. The Contractor shall ensure that all his employees are fully conversant with established regulations and the Health & Safety requirements.
2. The Contractor shall provide his staff with PPE comprising but not necessarily limited to, hard hats, eye protection, hand protection, overalls and industrial boots, plus safety facilities comprising a mobile telephone, safety/warning signs, a clean water supply and a changing room and washing facilities. Emergency equipment shall also comprise as a minimum, a first aid kit and a fire extinguisher.
3. The Contractor shall submit to Engineer for approval a Health & Safety Plan at least two weeks prior to commencement of the site works for review by Engineer. The Contractor's Health & Safety Plan shall include procedures to be adopted in the event of a medical emergency. Such submission shall in no way relieve the Contractor of any of his Health & Safety responsibilities for the work, personnel, public, etc.
4. The Contractor shall allow the Engineer's Safety Officer free and complete access to the site at all times.
5. The Contractor shall ensure that at least one member of his staff at each Investigation location is fully qualified in First Aid.

N. Hazardous and Contaminated Ground:

1. If evidence of hazardous or contaminated ground is encountered the Contractor shall cease work and inform Engineer immediately and agree on a revised method of working appropriate to the nature and level of contamination encountered.

O. Environmental Best Practice:

1. The Contractor shall plan and order all his activities to ensure that the environmental principles of stewardship and sustainability are achieved. Relevant local environmental protection regulations shall be applied.
2. The Contractor shall take all necessary precautions to prevent any pollution or contamination of the site or of adjacent ecosystems. No spillages or escape of dangerous, deleterious or contaminative waste or fluids shall be allowed to occur on the site whatsoever.
3. In addition to the above general requirements, particular areas for protective action are:

    a. The avoidance of pollution of groundwater.
    b. The preservation of all terrestrial and marine flora and fauna.
    c. The avoidance of nuisance due to sound, vibrations, mud, dust and fumes.

4. The Contractor shall demonstrate in his written Method Statement(s) his proposals to minimize environmental impact and satisfy the above requirements.
5. The following issues as a minimum shall be addressed in the Method Statement:

    a. Plant which leaks any fuel, lubricant or hydraulic or other fluids shall not be used.
    b. Bio-degradable hydraulic fluid only shall be used.
    c. Plant shall be maintained to ensure efficiency and to minimize emissions.
    d. Plant shall be steam-cleaned prior to delivery to the site.
    e. Fuel and oil shall be stored and maintained in a secure and clean manner.
    f. Refueling or servicing of plant shall be carried out in designated locations away from water bodies or the sea. Refueling shall be supervised and shall be carried out by pumping through a trigger-type delivery nozzle.
    g. An adequate supply of oil absorbent materials shall be readily available on site at all times.

P. Any spillages shall be immediately contained, removed from site and disposed of at a licensed facility, the Engineer being promptly informed.

## PART 2 - PRODUCTS

### 2.1 GENERAL

A. Details of all plant and equipment to be used on the project shall be notified to the Engineer before use on site.

B. The Contractor shall provide all necessary equipment and tools to carry out the described scope of work, considering that samples have to be taken in the required quality for laboratory testing.

C. The Contractor shall properly maintain all equipment in good condition and shall deploy a sufficient stock of spares in the event of equipment breakdown.

### 2.2 DRILLING AND SAMPLING TOOLS

A. Drilling Equipment shall be in good condition adequate for performing the intended works, in-situ testing and retrieval of samples. Provide calibration certificates for the approval of the Engineer prior to mobilizing equipment to site.

B. For tools' specification, refer to:

1. ASTM D5875 for specifications of cable-tool drilling.
2. ASTM D1452 for specifications of solid-stem augers.
3. ASTM 6151 for specifications of hollow-stem augers:
4. ASTM D1586 and ASTM D3550 for specifications of drive thick wall sampling.
5. ASTM D 1587 for specifications of push thin wall sampling.
6. ASTM D5782, ASTM D5783, ASTM D5876 for specifications of rotary drilling equipment.
7. ASTM D6169 for specifications of soil core sampling.
8. ASTM D2113 for specifications of rock coring.

C. Drilling Fluid:

1. Comply with environmental regulations on specifications of drilling fluid.
2. Submit data sheets and mix design for the Engineer for approval.

### 2.3 MATERIAL FOR PRESERVING SOIL SAMPLES

A. Furnish Sealing Wax, Wood Disks, Plastic Bags, Plastic Buckets, Tape, Cheesecloth, Caps, Expandable Packers, Jars, Bags, Packing Material, Insulation, Sample Cube Boxes, Cylindrical Sample Containers, Shipping Containers, Identification Material following requirements of ASTM D4220

### 2.4 ROCK CORE BOXES

A. Furnish core boxes according to the requirements of ASTM D2113.

PART 3 - EXECUTION

3.1 BOREHOLES

A. Layout, Depth and Diameter:

1. Borehole drilling shall be at the locations shown on the Drawings.
2. If location changes are deemed necessary, whether for regulatory purposes or based on site constraints, the new locations shall be approved by the Engineer. Fix positions using proper surveying equipment and record the co-ordinates and levels for logging and reporting.
3. Drill boreholes to the depths shown on Drawings. If rock is encountered, continuous coring shall be carried for a minimum of 5.0 m into good quality rock or to the depths shown on Drawings whichever is achieved first or as directed by the Engineer. Good quality rock is defined as rock with rock quality designation (RQD) value more than 75% for a core run of 1.0 m and a core recovery of not less than 90%.
4. Borehole diameters shall follow the diameter of samples intended to be retrieved based on different testing requirements. If casing is not used, a borehole 6 to 19 mm greater in diameter than the outside diameter of the sampler shall be sufficient. In soils containing irregular hard and soft pockets that cause deviation of the drill bit or in soils that tend to squeeze, a slightly larger clearance, i.e., 12 to 19 mm, may be required. When casing is used, the hole shall be drilled 6 to 25 mm larger than the OD of the casing.
5. In general, boring in soils associated with undisturbed sampling shall be to a minimum diameter of 150 mm. Boring associated with SPT testing only could be less, but not less than 75 mm in diameter. Coring in rock shall correspond to “N” sized borings to obtain rock cores of minimum diameter of 76 mm.

B. Boring Methods:

1. Auger Borings (ASTM D1452, ASTM D6151):

    a. Use Augers for borings above the groundwater table only. Use in soils containing sufficient fines and cohesion to prevent the hole from caving.
    b. Consider wherever restrictions on the use of drilling fluid are in-place, such as: to drill in water sensitive formations, to eliminate the potential for hydraulic fracturing in embankment dams and to decrease the environmental impact of investigations.
    c. Always use with other sampling techniques. Do not rely on disturbed samples from cuttings to establish information on subsoil stratification as cuttings from different strata could mix up.
    d. At a depth of about three- to four-hole diameters above the top of the intended sample, additional care shall be taken to prevent disturbance by decreasing the rate of hole advance.
    e. Use Hollow-stem augers for continuous sampling. Use double tube HSA sampling system with wireline latching system for sampling intact/ undisturbed specimens.

2. Push and Drive Boring (ASTM D1586, ASTM D1587, ASTM D3550):

    a. Use push or drive boring as a non-rotary advancement and sampling method for disturbed or intact/undisturbed sampling. Assess sample disturbance based on the sampler used and the sampling procedure.
    b. Use to supply data on penetration resistance of soil.

3. Cable Tool Drilling (ASTM D5875):

    a. Use Cable tool drilling/Percussion drilling only as primary advancement method to install the primary casing subject to the Engineer’s approval.

4. Rotary Drilling/Soil Coring (ASTM D5782, ASTM D5783, ASTM D5876, ASTM D6169):

a. Bottom discharge rotary bits are not acceptable for advancing the borehole. Side discharge bits may be used with caution. Jetting through an open-tube sampler to clean out the borehole to sampling depth is not permitted.
b. Use air-rotary drilling in friable sandstones, marls and collapsible soils and other water sensitive formations.
c. Recover continuous cores of all cemented material, exercise great care to obtain good recovery of weakly cemented material. Core barrel shall be fitted with a coring bit most suited to formations being drilled and which yields best recovery.
d. Use double core barrels and wireline latching mechanism instead of drill rod retrieval and sampling.

5. Rock Coring (ASTM D2113):

a. Use "N" size cores as a minimum to obtain rock cores of at least 76 mm in diameter. Use larger diameter cores for delicate, weakly lithified or weak rock formations.
b. Single tube core barrels are not permitted unless authorized by the Engineer. Use instead swivel type- double tube core barrels.
c. Use triple tube core barrel for highly fractured and poor-quality rock.

C. Borehole Stabilization:

1. Support the borehole with casing as necessary to prevent collapse of sides.
2. Use drilling mud to build a filter cake that effectively controls caving only when this will not interfere with sampling of soil, groundwater monitoring or in situ testing.
3. Maintain excess hydrostatic pressure in the borehole to avoid caving.
4. Withdraw sampler slowly from the borehole to avoid creating negative hydrostatic pressure below the sampler. Raise and lower the drill string slowly to minimize hydrostatic pressure changes.
5. Operate pump pressures as low as possible to minimize surge pressures. Drill formations no faster than solids are removed from the drill bit.

D. Drilling Fluid:

1. Compressed Air:

a. Use in water sensitive formations, such as collapsible soils, to maintain the natural moisture content of the samples
b. Avoid excessive air pressure (exceeding 350 KPa) in order not to damage the formations.
c. Avoid excessive annular velocity (exceeding 45 m/s) in order not to erode the borehole sides.
d. Use high volume air compressor to efficiently remove cuttings.
e. Use with caution in areas prone to hydraulic fracturing.

2. Air-entrained Foam:

a. Add foaming agents to compressed air in formations with high moisture content.
b. Submit product data sheets and manufacturer recommendations for approval prior to use.

3. Clean Water:

a. Do not use in water sensitive formations.
b. Use in borings associated with environmental testing, permeability testing, groundwater monitoring and seepage analysis.

4. Bentonite Mud:

a. Comply with standard grades of American Petroleum Institute (API) Specification 13A (American Petroleum Institute 1983).
b. Wherever environmental regulations restrict the use of additives found in standard grade bentonite, use pure sodium bentonite or revert to polymer mud.

5. Polymer Mud:

a. Assess the gel strength required to have a satisfactory filter cake. Mix with bentonite in case environmental regulations permit this.

E. Boring Through Obstructions:

1. If an obstruction is encountered which prevents further progress in boring, attempt to break through the obstruction by chiseling. If size or composition of obstruction is such that little or no progress is made by chiseling, inform the Engineer and if instructed use rotary coring methods to drill through and obtain cores of the obstruction not less than 100 mm diameter.
2. If boring shows that the obstruction is bedrock, continue rotary core drilling to depth and diameter required by the Engineer to prove continuity and engineering characteristics of formation.
3. If boring shows that the obstruction is a boulder, ledge of rock or any other object underlain by soil, then request direction from the Engineer on whether:

a. To make the necessary arrangements to continue boring, in situ sampling and testing below the obstruction until reaching the required depth.
b. Or to abandon the borehole and drill another.

F. Soil Sampling-Generally:

1. Samples shall be representative of a soil formation. Samples from mixtures of different soil layers are nonrepresentative and shall not be used for visual identification, logging or testing.
2. Consider the following factors affecting sample disturbance prior to selection of sampling method and sampler types:

a. Sampler characteristics: Area ratio, inside clearance ratio, outside clearance ratio, length-to-diameter ratio
b. Advancement method and sampler recovery
c. Borehole stabilization and type of drilling fluid.

3. Consider the sample size and dry weight needed for testing prior to selection of sampler size:

Table 1: Minimum sample size and dry weight for testing

| **Sample Type** | **Test** | **Minimum Sample Diameter[1] (cm)** | **Minimum Dry Weight (Kg)** |
|---|---|---|---|
| Undisturbed | Unit weight | 7.6 | |
| | Permeability | 7.6 | |
| | Consolidation | 12.7 | |
| | Triaxial compression | 12.7 | |
| | Unconfined compression | 7.6 | |
| | Direct shear | 12.7 | |
| Disturbed | Water content | | 0.2 |

| | | | |
|---|---|---|---|
| | Atterberg limits | | 0.2 |
| | Shrinkage limits | | 0.2 |
| | Specific gravity | | 0.1 |
| | Grain size analysis | | 0.2 |
| Reconstituted | Standard compaction | | 13.5 |
| | Permeability | | 0.9 |
| | 10.2-cm-diam consolidation | | 0.9 |
| | Direct shear | | 0.9 |
| | 3.6 cm-diam triaxial (4 points) | | 0.9 |
| | 7.2 cm-diam triaxial (4 points) | | 4.5 |
| | 15, 30, or 38 cm-diam triaxial (4 points) | Coordinate with laboratory | |
| | Vibrated density | Coordinate with laboratory | |
| [1] All particles pass the U.S. Standard Sieve No 4 (3.8 mm). | | | |

G. Sampling Methods-Undisturbed Sampling:

1. Apply strictly controlled conditions in order to minimize the structural disturbance of the samples. Use the appropriate samplers based on site conditions. The 200 mm of soil immediately above the level of soil to be sampled shall be removed without the casing being lowered. Carefully clean boreholes before sampling. Oil the sampling tool inside and out. Carefully clean the borehole.
2. Consider thin-wall open tube samplers (ASTM D1587) for intact sampling of soft deposits with fines greater than 12%. Force the tool into the soil by pushing or jacking. Hammer driving is not allowed unless authorized by the Engineer. Check the pushed distance carefully to avoid compressing the sample.
3. Consider thin-wall Piston samplers (ASTM D6169) to retain samples not retained by open samplers and reduce contamination. Use with care to avoid malfunctioning of the sampling mechanism.
4. Consider rotating soil core samplers such as Denison and Pitcher Samplers (ASTM D6169) or double tube HSA sampling system (ASTM D6151, ASTM D6169) for very stiff or cemented deposits.

H. Sampling Methods-Disturbed Sampling:

1. Recover undisturbed samples from thick wall samplers (ASTM D1586, ASTM D3550).
2. Drive the samples into the soils and record the penetration resistance as per standards.
3. Do not recover disturbed samples from boring tools and cuttings unless authorized by the Engineer.

I. Sampling Frequency:

1. Obtain intact samples in all cohesive soils or mixed soil having sufficient cohesion at depth intervals of 1m, or as indicated.
2. Perform standard penetration test as specified to recover a disturbed sample of soil at intervals of not more than l m in the top 5 m and at intervals of 1.5 m or at the change of each strata thereafter, unless otherwise instructed by the Engineer.
3. Obtain samples at such spacing to ensure that samples from borehole, either in the form of undisturbed samples, standard penetration test samples or disturbed samples are obtained for every 1 m depth bored.
4. Obtain samples of each strata encountered.

J. Rock Sampling and Preservation of Cores:

1. Coring runs shall be limited to not more than 2 m. However, if core recovery is less than 80% the run shall be reduced until an acceptable recovery for subsurface conditions is obtained, as approved by the Engineer.
2. Remove core from core barrel by methods that cause least possible disturbance.

3. Where split inner core barrels are not in use, extract core by steadily applied pressure. Extraction by means of hammering the barrel or explosive extrusion under high air pressure or water pressures will not be permitted. After extrusion, place core in a purpose made core box.
4. First seal with aluminum foil and subsequently cover with wax, sections of core which are weak and friable, formed of rocks or soils which are likely to dry out or otherwise alter in nature with time, before placing in core box.
5. Place cores in core boxes that adequately preserve cores.
6. All core boxes shall be photographed as soon as possible after extraction. Photographs shall clearly show weak rock cores and those subject to disintegration on recovery and shall be free from distortion and shall include a scale and colour chart. All boxes shall be clearly labelled and show the depth to the top and bottom of each core run.
7. Refer to ASTM D2113 for guidance.

K. Exploratory Excavations and Sampling:

1. Excavate exploration pits to a plan area of not less than 1.5 square meters to the depths shown on the drawings. Excavation could be terminated before reaching the intended depth If groundwater or bedrock are encountered as directed by the Engineer.
2. Use of machines is permitted. Manual excavation shall be used prior to undisturbed sampling.
3. Excavate pits to an open cross-sectional area large enough to permit efficient excavation and shoring (if necessary), engineering and geological inspection and photographing of the subsurface soils and manual undisturbed sampling from within the test pit.
4. Provide all pumping and take all measures (e.g. sheet piling, timbering etc.) to ensure stability of adjacent structures or installations and safe conditions for descent into and working in the pits. While observations are in progress take all necessary steps to exclude water from test pits.
5. All open exploratory excavations must be provided with suitable barricades, such as fences, covers, or warning lights, to protect pedestrians, livestock or wild animals, or vehicular traffic from accidents. Excavations shall be protected in accordance with all applicable safety regulations.
6. Take disturbed samples every 1m or at every change of strata, whichever is the least. Minimum weight of samples shall be as specified in ASTM D6913/D6913M for classification.
7. Take a minimum of two representative samples suitable for compaction testing from each test pit.
8. Take undisturbed samples, as required by the Engineer, in accordance with ASTM D 7015.

    a. Carry out a field density test next to each sample location.
    b. Sampling requires trimming tools and proper sampling containers and careful advancement.
    c. Push and Trim in increments to minimize disturbance. Retain trimming for water content testing.
    d. Remove the sample using wireline or chainsaw/shovel/knife.
    e. Place 3 minimum layers of cheesecloth and wax on sample sides

L. Handling, Preservation and Shipment of Samples

1. Properly label and preserve each sample and protect from temperature extremes and moisture changes. Undisturbed samples must be handled and preserved in a manner to preserve stratification or structure, water content, and in situ stresses, to the extent possible.
2. Immediately after taking samples from the boreholes, remove a 25 mm thick layer from each end and seal ends with a thick coating of paraffin wax or other wax approved by the Engineer. Store the 25 mm thick layers in an airtight container for classification testing. Place a close-fitting lid or screwed cap over each sample tube end and make tube airtight. Send samples to the laboratory, suitably packed to prevent damage or disturbance. Number and label each tube so that sample can be identified indicating borehole, soil stratum, depth at which it was taken and date.

3. In general, carbon steel tubes shall not be used if the samples are to be stored in the tubes for an extended period of time to avoid contamination by corrosion. If extended storage is required, samples shall be extruded and sealed within another suitable container. Containers made of alternative metals or wax-coated cardboard tubes shall be considered.
4. Place disturbed samples in plastic bags and seal to prevent changes in soil moisture.
5. Keep all descriptive labels and designations on sample jars, tubes, and boxes clean and legible until final delivery of samples. Samples shall be delivered within the time limits specified by the Engineer.
6. Take every precaution to avoid damage to samples as a result of careless handling and undue delay in shipping. Minimize handling of samples and take care in transporting samples of soil and cores of rock from the site to the testing laboratory. Samples shall be shipped in containers of sufficient durability to protect the samples from any damage during shipment. Protect samples against vibrations. Avoid exposing samples to precipitation, direct sunlight, temperatures in excess of 38 degrees C. Where possible, use transport manned by skilled personnel and arrange that those responsible for transporting samples are informed of the need to avoid unnecessary disturbance.
7. Refer to ASTM D4220 for guidance on the preservation and shipment of samples.

M. Boring and Sampling Records:

1. Soil and rock description shall be in accordance with ASTM D2488. Alternatively, the following general scheme could be used in the description of the surface geology and all soil and rock samples.

Table 2: Soil and rock description

| **SOIL** | **ROCK** |
|---|---|
| **Prefixes** | |
| Strength or relative density<br>Structure and weathered state<br>(if appropriate)<br>Colour<br>Secondary constituents<br>Particle shape and grain size<br>(for coarse grained soils) | Colour<br>Grain size<br>Texture and structure<br>Weathered or alteration state<br>Discontinuities |
| **SOIL NAME (in capitals)** | **ROCK NAME (in capitals)** |
| **Suffixes** | |
| Plasticity (for fine grained soils)<br>Minor constituents and lithological characteristics<br>Other information of special engineering interest<br>Geological formation (in brackets) | Mechanical strength<br>Minor lithological characteristics<br>Other information of special engineering interest<br>Geological formation (in brackets) |

2. All pertinent borehole, test pit and sample data must be recorded in a log as detailed in Part 1.

N. Backfilling and Reinstatement:

1. Preserve all holes in good condition until final measurement and until the records and samples have been accepted. Start backfilling only when authorized by the Engineer.
2. Unless directed otherwise, all boreholes shall be grouted from the bottom of the hole to within 600 mm of the ground surface using a cement grout mixture, or bentonite/cement mix. All grout shall be pumped through a tremie pipe that is inserted to the bottom of the boring to ensure that the grout fills the full extent of the hole. The remaining un-grouted top 600 mm of the hole shall be backfilled with local soil and tamped.

3. Test pits shall not be backfilled without the Engineer's instruction. Place backfill into test pit in layers, each successive layer being compacted. Reinstate the surface to the condition existing before excavation to the satisfaction of the Engineer

## 3.2 INSITU TESTING FOR GEOTECHNICAL PURPOSES

A. General:

1. All preparation, testing and reporting shall be in accordance with the relevant referenced standard. The Contractor may undertake testing to alternative standards where these have been agreed with the Engineer prior to the commencement of site works.
2. The following information shall be submitted for each test record to be included in the daily report, preliminary log and factual report:

    a. Date of Test.
    b. Exploratory hole number and location.
    c. Original ground level at test site.
    d. Depth and location of test or depths covered by test
    e. Information on groundwater levels in the exploratory hole during testing.
    f. Soil type and description at the test location as identified from ground samples taken at the test level.

3. All results shall be reported in SI units.
4. Where load, displacement, pressure or other measuring equipment used during the investigation fieldwork necessitates regular calibration, such calibrations shall be carried out in accordance with the relevant standard or equipment manufacturer's instructions following award of the Contract but prior to use in the Works. Evidence of calibrations and copies of calibration charts shall be supplied to the Engineer prior to commencing work and when otherwise requested.

B. Standard Penetration Test (SPT):

1. SPTs shall be carried out in accordance with ASTM D1586/1586M, BS EN ISO 22476-3 or other equivalent Standard to the approval of the Engineer.
2. Evidence of calibration of the weight and drop of the trip hammer shall be provided for each set of equipment used. Before any test is attempted, all loose and disturbed material shall be removed from the bottom of the exploratory hole.
3. SPT shall be performed as specified to recover a disturbed sample of soil at intervals of not more than l m in the top 5 m and at intervals of 1.5m or at the change of each strata thereafter, unless otherwise instructed by the Engineer
4. All external and internal faces of the SPT split spoon sampler shall be smooth and free from scars made by tools and rocks. A cone-ended adapter with a 30° half angle shall be available to replace the open-ended driving shoe for use in gravelly soils, or when directed by the Engineer.
5. The results of SPTs shall be reported as the number of blows for the first 150 mm penetration (seating drive), in 75mm increments, and subsequently the number of blows for each 150mm of penetration over the final 300mm. The SPT 'N' value shall be recorded as the sum of the number of blows over the final 300mm of penetration. Examples are given below:

    a. Seating drive No of blows: 3, 4 (seating drive = 7)
    b. Final 300 mm No of blows: 7, 9, 12, 16 (SPT 'N' = 44)

6. If any increment of 75mm of penetration (including the seating drive) is not achieved after 50 blows of the drive hammer, or where the total number of blows, excluding the seating drive, reaches 100, the number of blows and the penetration achieved (in millimeters) shall be recorded and the test shall be terminated. For example:

    a. Seating drive No of blows = 21, 50 for 70 mm (seating drive = 71 for 145 mm)

b. Final 300 mm No of blows = 31, 34, 35 for 55 mm (SPT 'N' = 100 for 205 mm)
c. The water level in the borehole at the time of the test shall be recorded. When testing below the groundwater table, particular care shall be taken to maintain the water level in the exploratory hole at or above the water table in order to prevent piping disturbance of silt, sand, gravel, or laminated clay/silt.

7. Additionally, the Contractor shall submit the following:

a. Borehole diameter
b. Top of sample depth and sample number
c. Number of blows for each 0.15 m increment
d. Hammer type and energy transfer ratio ER (%)

C. Mechanical Static Cone Penetration Test- Dutch CPT:

1. This test shall be performed as per ASTM D3441 or BS EN ISO 22476-12 and BS EN 1997-2 or other equivalent Standard to the approval of the Engineer.
2. Carry out tests at convenient intervals generally not exceeding 250 mm until required depth of penetration has been reached.
3. If progress becomes impossible before the specified depth has been reached, drill a borehole to the level where progress ceased and continue test from bottom of this bore-hole or successive boreholes drilled in like manner until specified depth has been reached.
4. Results shall include the following:

a. Full description of apparatus intended to be used, its mode of operation.
b. Calibration certificate for all sensors of the used cones combined penetration resistance of cone and sleeve plotted against depth.
c. Penetration resistance of cone plotted against depth.
d. Penetration resistance of sleeve plotted against depth.
e. Friction ratio Rf plotted against depth.
f. Interpretation of results with test observation and anomalies.

D. Electronic Friction Static Cone and Piezocone Penetration Test- CPT /PCPT:

1. This test shall be performed as per ASTM D5778 or BS EN ISO 22476-1 and BS EN 1997-2 or other equivalent Standard to the approval of the Engineer.
2. Submitted results shall include the following:

a. Full description of apparatus and its mode of operation,
b. Calibration certificate for all sensors of the used cones and pore water pressure transducers,
c. Correction factor for tip and sleeve resistance reading,
d. Combined penetration resistance of cone and sleeve plotted against depth,
e. Penetration resistance of cone plotted against depth,
f. Penetration resistance of sleeve plotted against depth,
g. Pore water pressure plotted against depth,
h. Friction ratio Rf plotted against depth,
i. Interpretation of results with test observation and anomalies.

E. Dynamic Cone Penetration Test/Dynamic Probing:

1. This test shall be performed as per ASTM D6951/D6951 M or BS EN ISO 22476-2 and BS EN 1997-2 or other equivalent Standard to the approval of the Engineer.
2. At time of tender give full description of apparatus intended to be used, its mode of operation and its calibration with the standard penetration test.
3. Present results in the form of a graph of depth plotted against number of blows or any convenient unit of penetration

F. Menard Pressuremeter Test:

1. Method used shall conform to BS-EN-ISO 22476-4 or other equivalent Standard to the approval of the Engineer. The unload/reload cycling shall be performed to NF P 94-110-1.
2. Submit with tender all technical information pertaining to the pressuremeter apparatus to be used. In addition, names and qualifications of technicians who will conduct the pressuremeter test shall be submitted. Such personnel shall have a minimum experience of 5 years in pressuremeter testing.
3. Make tests in boreholes as directed by the Engineer after results of preliminary boreholes are available. Should carrying out the pressuremeter tests require a change in the borehole size, inform the Engineer. Number and depths of tests shall be as instructed by the Engineer.
4. The equipment and method used to prepare the test shall cause the least possible disturbance to the soil at the cavity wall.
5. When testing soils, the pressuremeter tests must be performed immediately after the hole is drilled.
6. The minimum spacing between two consecutive tests shall be greater than (11⁄2) times the length of the inflatable part of the probe, common spacing range from 1 to 3 m, or as directed by the Engineer.
7. The instrument shall be calibrated before each test to account and compensate for pressure losses and volume losses.
8. The test can be terminated when sufficient data has been accumulated for the intended purpose, within the full capabilities of the equipment. These will normally be:

    a. When the pressure reaches at least 5 MPa, or
    b. When the volume of liquid injected into the central measuring cell exceeds 700 cm3, or
    c. When the probe bursts.

9. Injected liquid volume readings shall be taken at 0, 15, 30 and 60 seconds for each pressure increment.
10. For each test, submit to the Engineer the following parameters:

    a. Probe type and dimensions
    b. Pressure and volume loss calibration curve
    c. Initial volume of the probe Vc
    d. Raw and corrected pressure meter test curves f (P) = V (60 s)
    e. Creep curve G(P) = Δ (V60/V30): the difference between two readings at 30 and 60 seconds;
    f. Elevation zc of the pressure transducer
    g. Menard deformation modulus Em
    h. Limiting pressure Pl
    i. Creep pressure Pf
    j. Ratio Em/Pl
    k. Em, Pl and Pf plotted versus depth

G. Plate Load Test:

1. This test shall be performed at locations directed by the Engineer. Plate load test apparatus shall be conforming to the requirements of DIN 18134 or other equivalent Standard to the approval of the Engineer.
2. Plate load test apparatus shall be calibrated before performing the test
3. Perform this test in soaked and unsoaked conditions for assessment of soil collapse potential. Soaking for 24 hours shall be carried out at a stress level of 200 kPa, unless otherwise directed by the Engineer. After 24 hours soaking, the test shall be continued until reaching a stress level of 600 to 800 kPa depending on jack capacity and in all cases beyond collapse stress level. Then the load shall be released by stages as per DIN 18134.
4. At the location of the test, soil samples shall be taken for performing the following laboratory tests:

    a. grain size analysis (3 at each location)
    b. Atterberg limits (3 at each location)

c. field density tests (3 at each location)

5. The test report shall include the following information and parameters:

a. Plate diameter
b. Dial gauge reading and corresponding normal stresses
c. Load-settlement curve
d. Strain Modulus Ev
e. Modulus of subgrade reaction

H. Flexible Dilatometer Test:

1. Method used shall conform to BS-EN-ISO 22476-5 or other equivalent Standard to the approval of the Engineer.

I. Vane Shear Test:

1. Vane shear test shall be performed to ASTM D2573/D2573M or BS EN ISO 22476-9 and BS EN 1997-2 or other equivalent Standard to the approval of the Engineer.
2. The torque measurement device shall be calibrated prior to testing.
3. After completion of standard test, measure remolded shear strength of soil when instructed. Torque measuring instrument shall be disconnected from extension rods and vane turned through at least six complete revolutions. Allow a period of at least five minutes to elapse and then repeat vane test.
4. Conduct intact and remolded vane tests at intervals of not more than l m in the top 5 m, subsequently at intervals of 1.5 m and at the change of each strata.
5. Submit the following data/results:

a. Size and shape of the vane (double tapered, single tapered, or rectangular) and cross area;
b. Calibration information and plot for the torque measurement device;
c. Peak undrained shear strength Su with the peak torque value Tp;
d. Remoulded shear strength Sur with the number of revolutions and residual torque value Tr, Time to failure tf;
e. Sensitivity Ratio Sr;
f. The mobilized undrained shear strength Cu including the vane correction factor μ.

J. Field Density Test:

1. This test shall be performed at locations directed by the Engineer. The sand cone method shall be according to ASTM D1556, BS1377-9 or other equivalent Standard to the approval of the Engineer.
2. Field density test by sand replacement method, according to ASTM D4914/D 4914M or AASHTO T19 might be used, only with the approval of the Engineer.
3. This test method is applicable for soils without appreciable amounts of rock or coarse materials in excess of 38 mm in diameter.
4. This test shall be used to determine the in-place density and unit weight of soils using a sand cone apparatus, provided the natural void or pore openings in the soil are small enough to prevent the sand used in the test from entering the voids. The soil being tested shall have sufficient cohesion or particle attraction to maintain stable sides on a small hole or excavation, and be firm enough to withstand the minor pressures exerted in digging the hole and placing the apparatus over it, without deforming or sloughing. Also, this test method is not suitable for organic, saturated, or highly plastic soils that would deform or compress during the excavation of the test hole.

## 3.3 GROUNDWATER MONITORING, SAMPLING, AND INSITU GEO-HYDRAULIC TESTING

A. Groundwater Observations in Boreholes:

1. When groundwater is encountered in an exploratory hole, boring/drilling or excavation shall immediately be suspended and the depth from ground level of the point of water entry recorded, together with the depth of any casing in use at the time. For boring works (or drilling works where the drilling flush does not 'mask' water strikes) work shall be suspended for a 20-minute period after any water strike and any change in water level over this period shall also be recorded. On each occasion when groundwater is recorded, the depth of the exploratory hole, the depth of any casing and the time on a 24-hour clock shall also be recorded.
2. Where artesian conditions are encountered, the Contractor shall immediately inform the Engineer and agree upon a method for assessing the encountered conditions.
3. Water levels shall be recorded and shown on borehole logs.

B. Standpipes and Piezometers:

1. Standpipes (or standpipe piezometers, if required) for monitoring general groundwater levels or changes in groundwater level in exploratory holes shall be installed in boreholes as shown on the Drawings, or as otherwise instructed by the Engineer.
2. Standpipe shall comprise a rigid polyvinyl chloride or galvanized iron pipe 45 mm minimum diameter having at its lower end an approved porous filter element or alternatively perforated for a length of at least 500 mm.
3. Surround filter or bottom of pipe with sand or sand and gravel mix graded to prevent entry of soil particles into pipe.
4. Place layer of graded mix in bottom of borehole prior to lowering stand-pipe.
5. Place sand or sand and gravel mix in position before withdrawing borehole casing.
6. Provide screwed cap to top of standpipe which is not to be less than 150 mm below ground level.
7. Protect cap with short length of 150 mm diameter pipe set vertically with upper end covered by paving slab set flush with ground surface.
8. All monitoring installations shall be protected from damage using 'stand-up' covers, appropriately robust protection and warning tape, with this maintained for a period as instructed by the Engineer.
9. Upon instruction by the Engineer, all monitoring installations shall be decommissioned by the Contractor, and backfilled with cement-bentonite grout in a pumpable mix, in such a manner as to minimize any subsequent depression of the ground surface due to settlement of the backfill.
10. When instructed by the Engineer, fill annulus above filter with a layer of bentonite - cement grout. Drop a plug of stiff bentonite in the form of balls down borehole and carefully tamp into place and follow by pumping down bentonite - cement grout to fill borehole to a level of at least 0.5 m above filter or as instructed by the Engineer.
11. When instructed by the Engineer, form a plug of bentonite - cement mix of stiff plastic consistency and carefully tamp into place below level of standpipe to form seal against upward flow of groundwater into standpipe from a deeper aquifer.
12. The top of each standpipe and piezometer tube shall be protected by a cover. The type of protective cover shall be approved by the Engineer.
13. When instructed by the Engineer, the Contractor shall install a protective fence around the top of a standpipe or piezometer.
14. Unless otherwise designated, piezometers and standpipes protection shall not be removed from the site.
15. During the period of the work, take two readings of water levels per day (one in the morning, another by end of the working day) in all standpipes by means of a dipmeter / water level meter or, if so directed, at more frequent intervals. When directed by the Engineer, return to the site at intervals to make additional water level readings.
16. If requested by the Engineer, install a data logging system for continuous remote monitoring of groundwater levels.

C. Groundwater Sampling:

1. Take a sample of groundwater as soon as sufficient water has entered borehole after boring has reached groundwater level.

2. If water has been added to borehole before reaching groundwater level, bail out all water in borehole and allow uncontaminated groundwater to seep back into borehole before sample is taken.
3. Where groundwater is sealed off by borehole casing and a lower aquifer is encountered, take a sample of water from this and any succeeding aquifers.
4. Sample of groundwater shall be at least 500 ml in volume and placed in clean jars or bottles already rinsed with the water to be sampled and labelled and stored as described in BS 5930.

D. Geo-Hydraulic Testing:

1. General:

a. Permeability tests shall be performed as part of piezometer installation procedures, both to obtain permeability information and to assure that the piezometer is working satisfactorily.
b. When performing a permeability test, provide the following data

1) Borehole number
2) Date and time of test
3) Borehole depth and diameter
4) Depth and diameter of casing
5) Depth to water level at start of test
6) Level of Packer(s), if applicable
7) length and diameter of test section of borehole, if applicable
8) Depth to water table and of any water inflows (including an estimate of amount of inflow)
9) Record of water level at each recording period
10) Lithologic logs
11) Screen lengths, if applicable
12) Filter pack thickness and length, if applicable
13) Thickness of saturated zone, if applicable
14) Initial head change from slug, if applicable
15) Details of any corrections made
16) Calculated permeability (m/sec)
17) Equations used for calculations
18) Plot of change in water level against time

2. Constant Head Test:

a. This test shall be performed as per BS EN ISO 22282-2, or other equivalent Standards to the approval of the Engineer.
b. Carry out constant head test as directed by the Engineer during sinking of boreholes.
c. After reaching the level of a pervious stratum in which a test shall be made, continue boring until penetration into stratum is not less than five times internal diameter of casing being used. Clean out borehole just to bottom of casing.
d. If casing is below level of groundwater, keep it full of water during cleaning and withdrawal of tools so that soil does not squeeze into it.
e. Discharge a metered supply of fresh clean water into the borehole. Water shall be free from silt or clay particles to avoid possibility of interstices of test section becoming plugged. If necessary free the water of foreign matter either by means of filtration or by use of settlement tanks.
f. Where practicable the temperature of added water shall be higher than that of the groundwater to preclude creation of air bubbles in ground which might greatly reduce acceptance of water.
g. In gravity tests adjust rate of flow of water supplied to borehole so that water level remains constant against a mark inside borehole casing near top. If it is impossible to maintain water level, a constant rate of flow producing a fluctuation of no more than 75 mm above and below the mark during a period of five minutes will be accepted. When steady state has been reached, record quantity of water entering

borehole over a fixed interval of not less than five minutes. Repeat until consistent results are obtained.

3. Falling Head Test:

   a. Where directed by the Engineer, carry out falling head test in accordance with BS EN ISO 22282-2 in place of the constant head test.
   b. Where conditions in bore-hole indicate that a permeable stratum has been reached, bail or pump out borehole to lower level of the water. Record water level until it returns to equilibrium.
   c. If it is impossible to lower water level in borehole either because soil is too permeable or because it flows into casing, carry out a pouring in test instead. In this test pour water into borehole until casing is full. Record water level at intervals until equilibrium position is reached.
   d. Normally record the water level in the borehole at intervals as indicated in BS EN ISO 22282:2012. Measure water level with a battery-operated indicator or similar approved instrument. Take reasonable precautions to prevent ingress of water into hole during test period.

4. Packer Test:

   a. Standard test method for determining transmissivity and storativity of low permeability rocks by in situ measurements using pressure pulse technique test standard ASTM D4631 Water pressure tests in rock BS EN ISO 22282-3.
   b. Tests may be carried out using a single or double Packer.
   c. Use only clean water with a temperature not less than that of groundwater.
   d. Carry out tests at three pressure increments and two decrements equivalent to P/3, 2P/3 and P, where P is the vertical overburden pressure at level of test. Other instructions regarding test pressure may be given at tender stage or during progress of the work.
   e. Record the following data:

      1) Q: rate of flow of water into borehole (liters/min)
      2) H: pressure head causing the flow (m)
      3) r: internal radius of borehole casing (m)

   f. Normally the flow rate at each pressure will be recorded at ten-minute intervals to a maximum of three periods or less if similar results are obtained in two consecutive periods.
   g. Pressure difference between each increment/decrement shall normally be not less than 35kN/m2, and pressure in Packer units shall be at least 300 kN/m2 greater than test water pressure loss at varying flow rates before use.

5. Slug Test:

   a. Test method for instantaneous change in head (slug) for determining hydraulic properties of aquifers
   b. Slug Tests shall be carried out at the locations and depths as determined by the Engineer in accordance with ASTM D4044/D4044M.
   c. If the water-level response in the slug test appears to be too sluggish or no response is apparent, the borehole may need to be redeveloped.
   d. The type of slug test (slug-in, slug-out) and mechanisms shall be determined based on the screen position. If the borehole screen is open above the water table, slug out is the only method acceptable.
   e. The change needs to take place rapidly (“instantaneous”) and of sufficient magnitude: at least 0.3045 m, preferably two to 1.22 m.
   f. If the water quality is such that direct discharge to the ground is not permitted, arrange for collection and disposal for standard slug-out testing. Discharge water must be disposed according to all applicable laws and regulations.

g. At each test borehole, establish and clearly mark the position of the selected reference point. Determine its elevation and record it.
h. Measurements taken manually shall continue until the water level has recovered about 80%.
i. After the slug-in test is finished and equilibrium reached, a slug-out test (reverse test) shall be performed as a check.
j. Compare volume of slug to actual water displacement in the borehole. Evaluate the quality of the data, and the method of analysis applicable to the results. If a clear trend was not established, the test may need to be re-run. Ensure that equilibrium has been reached before re-running a test in the same borehole.

6. Pumping Test:

a. This test shall be performed as per BS EN ISO 22282-4 or other equivalent Standards to the approval of the Engineer.
b. For permeability of rock, a preliminary fracture and joint analysis shall be conducted prior to laying out a pump test.
c. This test applies to pumping tests performed on aquifers whose permeability is such that pumping from a well can create a lowering of the piezometric head within hours or days depending on the ground conditions and the purpose. It covers pumping tests carried out in soils and rock.
d. Submit the following test result:

1) Drawdown and recovery of water levels in the test well and piezometers as a function of time;
2) Discharge from the test well as a function of time.

e. During the test, the test results shall be plotted graphically

7. Infiltrometer Test:

a. This test shall be performed as per ASTM D3385, BS EN ISO 22282-5 or other equivalent Standards to the approval of the Engineer.
b. The infiltrometer test is used to determine the infiltration capacity of the ground at the surface or shallow depth.
c. Submit the following test result:

1) For the constant head procedure: the infiltrated volumes as a function of time.
2) For the variable head procedure: the hydraulic head as a function of time.

d. The recorded volumes plotted on a graph.

8. Water Permeability Test in a Borehole using Closed Systems

a. This test shall be performed as per BS EN ISO 22282-6 or other equivalent Standards to the approval of the Engineer.
b. The tests are used to determine the permeability coefficient k in low permeability soil and rock lower than $10^{-8}$ m/s. It can also be used to determine the transmissivity T and the storage coefficient S.
c. Submit the following test result:

1) The pressure as a function of time,
2) The variation of volume at application of the pressure pulse at the beginning and at the end of the test.

9. Percolation/ Soakaway Test:

a. Soakaway tests are performed for drainage design as per BRE Digest 365.

## 3.4 LABORATORY TESTING

A. General:

1. The Contractor's personnel shall exercise quality control of sampling, ensure the use of representative samples, and prevent samples disturbance during shipping.
2. Assessment of conditions of samples and availability for testing shall run parallel to field work. The distribution of locations of soil and rock tests shall be evaluated periodically. If it becomes apparent in the application of the test data that coverage of field conditions is irregular, or missing in certain stratigraphic units, field sampling procedures shall be revised.
3. All preparation, testing and reporting shall be in accordance with the relevant referenced standard. The Contractor may undertake testing to alternative standards where these have been agreed with the Engineer prior to the commencement of site works.
4. The Contractor shall categorize samples in relation to applicability of testing according to ASTM D4220:

    a. Group A samples for which only general visual identification or profile logging is applicable.
    b. Group B samples for which only water content, classification, compaction and/or bulk sample testing is applicable.
    c. Group C samples for which density determinations, swell pressure, percent swell, consolidation, hydraulic conductivity, shear including cyclic and dynamic and any other intact specimen testing is applicable.
    d. Group D samples of fragile and sensitive material for which tests for Group C samples are applicable.

5. Calibration of load-displacement or other measuring equipment shall be carried out in accordance with the relevant standard or the manufacturer's instructions by an approved calibration service. Evidence of current and valid calibrations shall be supplied to the Engineer.

B. Schedule of Tests:

1. The Contractor shall supply a schedule of available samples and a proposed testing schedule in paper copy and in Microsoft Excel (.xls) format or other compatible spreadsheet program to the Engineer within three working days of completion of the borehole/ test pit to which they refer. The testing schedules shall then be reviewed by the Engineer and sent to the Contractor for implementation.
2. Testing shall not be undertaken on any sample until the Engineer approves the proposed testing schedule.

C. Soil Testing:

1. Testing of soils shall be carried out in accordance with the following Standards in Table 1 unless agreed otherwise with the Engineer.

Table 3: Soil tests

| Laboratory Test | ASTM Stand-ard | BS Standard | Comments |
|---|---|---|---|
| Grain Size Analysis | ASTM D6913/ ASTM D2487 | BS EN ISO 17892-4: 2016 Clause 5.2 | Use dry sieving only if the soil contains no clay and silt fraction or if the soil is not forming lumps.<br>Submit cumulative percentage by weight of soil passing test sieves plotted on a particle size analysis diagram. |
| Moisture Content | ASTM D2216 | BS EN ISO 17892-1 | Required for every sample, except clean sands and gravels. |

| | | | |
|---|---|---|---|
| | | | submit moisture content expressed as a percentage of dry weight of soil to two significant figures. |
| Particle Size Analysis by Sedimentation | ASTM D7928/ ASTM D1140 | BS EN ISO 17892-4: 2016 Clause 5.3 and 5.4 | Generally performed on soils finer than the No. 10 sieve size (medium sand and finer). Correlate with Atterberg limit tests to determine the plasticity of the soil.<br>Submit: cumulative percentages as for sieve analysis plus percentage less than 0.2 mm, 0.006 mm and 0.002 mm plotted on a particle size analysis sheet<br>loss of pretreatment to nearest 1%. |
| Dry and Bulk Densities | ASTM D4254 | BS EN ISO 17892-2 | |
| Plasticity Indices | ASTM D4318 | BS EN ISO 17892-12 | Required for every stratum of cohesive material; always have associated natural water content of material tested.<br>Submit: Liquid Limit (LL), Plastic Limit (PL), and Plasticity Index (PI) |
| Unconsolidated Un-drained Triaxial Com-pression Test | ASTM D2850 | BS EN ISO 17892-8 | Indicate whether undisturbed or remolded specimens are tested.<br>Submit all the data as per the specified references. |
| Consolidated Undrained Triaxial Compression Test | ASTM D4767 | BS EN ISO 17892-9 | Indicate whether undisturbed or remolded specimens are tested.<br>Submit all the data as per the specified references. |
| Consolidated drained Triaxial Compression Test | ASTM D7181 | BS EN ISO 17892-9 | Indicate whether undisturbed or remolded specimens are tested.<br>Submit all the data as per the specified references. |
| Consolidated drained direct shear Compres-sion Test | ASTM D3080 /3080 M | BS EN ISO 17892-10 | Indicate whether undisturbed or remolded specimens are tested.<br>Submit all the data as per the specified references. |
| Unconfined Compres-sion Test on Cohesive Soil | ASTM D2166 / D2166M | BS EN ISO 17892-7 | compressive strength to the nearest 2 $kN/m^2$ for values up to 50 $kN/m^2$, to the nearest 5 $kN/m^2$ for values of 50-100 $kN/m^2$ and to the nearest 10 $kN/m^2$ for values over 100 $kN/m^2$. |
| One Dimensional Con-solidation Test | ASTM D2435 / D2435M | BS EN ISO 17892-5 | |
| Specific Gravity of Soil Particles | ASTM D854 | BS EN ISO 17892-3 | |
| Chloride Content of Soil | AASHTO T291 | BS 1377-3 | Water soluble Procedure. |
| Sulphate Content of Soil | AASHTO T290 | BS 1377-3 | Water soluble Procedure. |
| Calcium Carbonate Content of Soil | ASTM D4373 | BS 1377-3 | Submit calcium carbonate content to nearest 1% by weight of original direct sample. |
| pH Value of Soil | ASTM D4972 | BS 1377-3 | |
| Chloride Content of Groundwater | ASTM D512 | BS 1377-3 | |

| | | | |
|---|---|---|---|
| Sulphate Content of Groundwater | ASTM D516 | BS 1377-3. | |
| pH Value of Groundwater | ASTM D1293 | BS 1377-3. | |
| Linear Shrinkage of Soil | ASTM D4943 | - | |
| One Dimensional Swell or Collapse Potential of Soils | ASTM D4546 | - | State type of water used to inundate the specimen. |
| Determination of The Dry Density/Moisture Content Relationship of Soil | ASTM D1557 - 12e1 or ASTM D698 - 12e2 | BS 1377-4 | State the amount of stone retained on 20 mm BS test sieve to the nearest 1%, and method of obtaining result i.e. weight of hammer used, number of layers compacted, size of mould used. |
| Determination of The California Bearing Ratio (CBR) | ASTM D1883 | BS 1377-4 | State the method of compaction, dry density and moisture content after the test, and if soaked, the time of soaking and amount of swell. |
| Alkali Silica Reactivity Test | ASTM C1260 | | |
| Sand Equivalent | ASTM D2419/ AASHTO T176 | BS EN 933-8 | |
| Clay Lumps & Friable Particles | ASTM C142/C142M | | |
| Drying and shrinkage test | ASTM D4943 | | |
| Dispersive test – Pinhole method | ASTM D4647 / D4647M | | |
| Dispersive test – Double hydrometer method | ASTM D4221 | | |

D. Rock Testing

1. Testing of rock shall be carried out in accordance with the following Standards in Table 2 unless advised otherwise by the Engineer.

Table 4: Rock tests

| TEST | STANDARD / REFERENCE |
|---|---|
| Natural moisture content of rock core specimen | ISRM Commission on Standardization of Laboratory & Field Tests. Suggested methods for determining water content, porosity, density, absorption & related properties & swelling & slake-durability index properties. Int. Jour. Rock Mechanics & Mining Sciences & Geomech. Abstract. 1979, 16(2), 141-156. |
| Porosity of rock core specimen | |
| Bulk density of rock core specimen | |
| Petrographic analysis of rock core specimen | ASTM D4992.<br>ISRM Commission on Standardization of Laboratory & Field Tests. Suggested methods for petrographic description of rocks. Int. Jour. Rock Mechanics & Mining Sciences & Geomech. Abstract. 1978, 15(2), 41-45. |
| Point load test on rock core specimen | ASTM D5731.<br>ISRM Commission on Testing Methods. Suggested methods for determining point load strength. Int. Jour. Rock Mechanics & Mining Sciences & Geomech. Abstract. 1985, 22(2), 51-60. |
| Uniaxial compressive strength of rock core specimen and static elastic modulus of rock core specimen | ASTM D7012.<br>BS EN ISO 17892-7.<br>Submit method of determination of Young's modulus and at what axial stress level determined. |

| | |
|---|---|
| Direct shear box test on rock core specimen | ISRM Commission on Testing Methods. Suggested methods for determining shear strength. Rock Characterization Testing and Monitoring: ISRM Suggested Methods. Brown, E.T., ed. Oxford: Pergamon Press, 1981. |
| Splitting tense strength of intact rock core specimen | ASTM D3967. |
| Direct Tensile Strength | ASTM D2936. |
| Slake durability index | ASTM D4644.<br>Rock characterization testing and monitoring: ISRM Suggested Methods. Brown, E.T., ed. Oxford: Pergamon Press, 1981. |
| cerchar | ASTM D7625<br>NF P94-430-1 |
| Rock hardness | ASTM D5873 |
| Los Angeles abrasion tests | ASTM C131 / C131M<br>BS EN 1097-2 |
| Soundness by magnesium sulphate | ASTM C88/C88M<br>BS 812 |
| Ten percent fines | BS 812 |
| Aggregate impact value | ASTM D5874<br>BS 812 |
| Polished stone value | BS 812 |
| Water absorption | ASTM D6473<br>BS EN 1097-6 |

2. Petrographic analysis, where required, shall include comments on particle angularity, cementation, porosity, skeletal structures and non-skeletal structures and general comments on grain characteristics, including secondary mineralization, the presence of gypsum, alteration, durability, and susceptibility to crushing.
3. For rock forms having soil-like characteristics, the index properties (Atterberg limits, moisture content, etc.) of these materials shall be determined prior to more comprehensive testing.

E. Other Laboratory Tests: The Contractor shall agree with the Engineer on the referenced test standard and equipment to be used for the test, and proceed accordingly. Test procedures shall be submitted with the results.

# E CONCRETE WORK

## E11 MAKING IN SITU CONCRETE

### E11:A DESIGN STANDARDS AND CLASSES OF CONCRETE

A131 DESIGN of reinforced concrete work has been based on the following standards:

| | | |
|---|---|---|
| design | : | ACI 318/318R |
| design loads | : | UBC-1997 |
| earthquake and wind loads | : | UBC-1997 |
| wind loads | : | Règles Neige et Vent, N65 et N84 modifiées 95. |

A171 DESIGN of liquid retaining structures has been based on ACI 350/350R.

A201 CLASSES OF CONCRETE: perform tests in accordance with ASTM C39/ASTM C39 M and ASTM C143/ASTM C143 M:

| Class of Concrete: | A** | C |
|---|---|---|
| Minimum cement content (kg/m3 of concrete) | 400 | 250 |
| Maximum free water cement ratio | 0.40 | 0.55 |
| Preliminary test cylinders: specified compressive strength at 28 days (kg/cm2) | 430 | 150 |
| Works test cylinders: specified compressive strength at 28 days (kg/cm2) | 350 | 110 |
| Method of compaction of concrete when placed | vibrated | vibrated |
| Slump value* (mm) | 70-80 | 100 |

* If superplasticizers are used to produce flowable concrete, then slump values are not applicable. The slump for concrete including admixture shall be in the range 200mm ±20mm.

** Silica Fume: to ASTM C1240, (5% to 10% of cementitious weight) is necessary to be added to the reinforced substructure concrete mixes and any external superstructure concrete affected by airborne environment.

The concrete mixes of the buried concrete and external concrete elements shall be dense and durable with "Very Low" permeability level satisfying the requirements of Clause 4651 below.

Air content: 2% maximum

A211 ALTERNATIVE TESTING: where the design standard is BS 1881, BS EN 12350, BS EN 12504, BS EN 12390-4 test cubes will be used for determination of compressive strength of concrete in accordance with BS 1881. In all such cases the equivalent characteristic compressive strength of test cubes shall be 1.25 times greater than the corresponding compressive strength for test cylinders specified in Clause A201.

MATERIALS AND PRODUCTS

E11:Y AGGREGATES, CEMENT, WATER AND ADMIXTURES

Y005 CONSTITUENT MATERIALS GENERALLY: to ASTM C33, BS EN 12620, BS 8500-1, BS 8500-2, BS EN 206 and to the requirements of Section E11:2 of this Specification.

Y205 SOURCES OF AGGREGATES: provide details of proposed sources of aggregates for approval.

Y210 EXPOSED AGGREGATE: obtain each type of aggregate which will be exposed in finished concrete work from one source and ensure adequate supplies can be maintained throughout the work.

Y225 COARSE AGGREGATES: Crushed and well graded non-reactive aggregates to ASTM C33 or BS EN 12620, from natural sources. Maximum size of aggregate in any member shall not be larger than 20 mm, in addition it shall not be larger than:

1/5 narrowest dimension between forms

1/3 depth of slabs

3/4 minimum clear spacing between reinforcing bars.

These limitations may be waived if, in the opinion of the Engineer, workability and methods of consolidation are such that concrete can be placed without honeycomb or void.

Y235 FINE AGGREGATES: Natural sand material or combined natural sand with crushed sand, non-reactive, from natural sources, to ASTM C33 or BS EN 12620.

Y260 LIGHTWEIGHT AGGREGATE: foamed or expanded blastfurnace slag to BS EN 13055-1.

Y305 PLUMS FOR CYCLOPEAN CONCRETE: broken stone spalls or boulders free from sharp or angular edges and ranging in size from 100 to 300 mm.

Y405 CEMENTS: obtain from approved sources. Delivery of cement is to be in sealed and branded containers in batches not exceeding 100 tonnes or in purpose made bulk delivery vehicles.

Y470 MODERATELY SULPHATE RESISTING PORTLAND CEMENT: to ASTM C150/C150M Type II or NL-53 Type P-RMS 42.5N, with C3A content ranging from 5% to 8% and minimum clinker content of 95%, shall be used in the substructure concrete mixes and external superstructure concrete. Cement meeting the requirements of rapid hardening Portland cement shall not be used and the heat of hydration shall not exceed 325 kj/kg at 7-days when tested according to ASTM C186. The heat of hydration of cement for use in massive/thick concrete elements shall not exceed 265 kj/kg at 7-days when tested according to ASTM C186.

Y475 SULPHATE RESISTING PORTLAND CEMENT: ASTM C150/C150M Type V or NL 53 Type P-RMS 42.5N, with C3A content not more than 5%, to be used for concrete elements in contact with sewage and plain/unreinforced substructure concrete elements.

Y480 HIGH ALUMINA CEMENT: do not use.

Y605 ADMIXTURES: do not use unless specified or approved.

Y620 RETARDING AND WATER REDUCING ADMIXTURE: to BS EN 934or ASTM C494/C494M, with low sensitivity to warm weather:

Y640 RETARDING ADMIXTURE: to BS EN 934 or ASTM C494/C494M, solution based on organic hydroxy or phosphate salts.

Y645 WATER REDUCING ADMIXTURE (PLASTICISER): to BS EN 934 or ASTM C494/C494M.

Y650 HIGH RANGE WATER REDUCING ADMIXTURE (SUPERPLASTICISER): to BS EN 934or ASTM C494/C494M.

Y700 Third Generation admixtures of the Polycarboxylate Ether type to ASTM C494 Type G shall be used in concrete mixes including silica fume.

Y805 WATER: to be clean, free from silt, organic matter, alkali, salts and other deleterious impurities. Obtain approval of source of supply. Test to BS EN 1008 and the maximum chloride content in the mixing water shall be maximum of 500 ppm.

Y810 CORROSION INHIBITING ADMIXTURES: Preparation and proportions shall be according to the manufactures recommendations. The dosage of admixture to be added to the concrete mix shall be confirmed based on successful trial mixes. The corrosion inhibitor shall satisfy the below requirements:

1. Comply with the requirements of ASTM C1582.
2. Have successful performance, based on laboratory test records when tested in accordance to ASTM G109, to demonstrate its effect on the corrosion of embedded steel in concrete i.e. inhibit chloride induced corrosion.
3. Have an established successful international and regional track-record for a period in excess of 20 years.
4. Be certified for potable water applications by accredited laboratories as per requirements of NSF Standard 61, or other equivalent authorities or standards.
5. Protect both anodic and cathodic components of the corrosion cell.
6. Non-polluting and non-harmful to plant life after flushing
7. Not be carcinogenic under Occupational Safety and Health Agency, NTP or IARC or other equivalent authorities or standards.

## WORKMANSHIP

### E11:1 GENERALLY

1101 CODE OF PRACTICE: concrete work is to be in compliance with the requirements of BS 8110.

1151 STANDARDS: composition of mixes, production of concrete and information to be provided are to be as specified and to BS 8500-1, BS 8500-2, BS EN 206 unless otherwise specified.

1201 STORE DIFFERENT AGGREGATES SEPARATELY on hard paved self-drained areas or in suitable hoppers or containers.

1301 STORE CEMENT dry in weathertight structures with raised floors or in suitable silos. Store different types and consignments of bagged cement separately and use in order of delivery.

1351 DO NOT USE cement manufactured more than six months prior to proposed use on the site.

## E11:2 TESTING AND APPROVAL OF CONSTITUENT MATERIALS

2051 PRELIMINARY TESTS AND SAMPLES: unless otherwise specified samples and tests are to be submitted or carried out and approval obtained before making concrete for use in the work.

2101 SAMPLES OF NATURAL AGGREGATES: submit preliminary samples of aggregates proposed for concrete work, to BS EN 932-1.

2151 PRELIMINARY TESTS ON NATURAL AGGREGATES: carry out preliminary tests to BS EN 1367-4, BS EN 1097-8, BS EN 932-5 for:

sieve analysis

clay, silt and fine dust

specific gravity

water absorption

bulk density, voids and bulking

moisture content

organic impurities

aggregate impact value

aggregate crushing value

10% fines value

crushing strength

aggregate abrasion value

chemical properties (soluble salt contents).

Carry out tests on every consignment from a new source and additional tests required by the Engineer.

2171 ALKALI AGGREGATE REACTIVITY TESTS: where aggregates are obtained from a previously unknown source, carry out the following additional tests as and when instructed by the Engineer:

| | |
|---|---|
| petrographic examination | to ASTM C295 |
| quick chemical test | to ASTM C289 |
| accelerated mortar bar test | to ASTM C1260 |
| rock cylinder test | to ASTM C586. |

2201 WORKS TESTS ON NATURAL AGGREGATES: during the progress of the work carry out tests to BS EN 1367-4, BS EN 1097-8, BS EN 932-5 for all items listed in Clause 2151.

2401 TEST CERTIFICATES FOR CEMENT and cementitious material: provide manufacturers' test certificates and obtain approval before starting trial mixes. Obtain manufacturer's test certificates for each consignment brought to the site during the progress of the work and retain on the site.

2451 TESTS ON CEMENT/cementitious material: representative samples from a minimum of ten bags from each batch are to be obtained and tested by methods prescribed for compliance with BS EN 197-1or ASTM C150/C150M and relevant BS EN/ASTM standards depending upon the type of cement/cementitious material. Batches and consignments that fail required cement quality tests are not to be used in the work and are to be removed from the site immediately.

## E11:3 DESIGN, BATCHING AND MIXING

3011 DESIGN concrete mixes to the requirements of ACI 301 and ACI 211.1 or BS EN 206.

3021 DESIGN concrete mixes to the requirements of ACI 211.1.

3051 EVIDENCE OF SUITABILITY: for each mix submit in writing details of:

proposed quantities of each ingredient per cubic metre of compacted concrete

evidence to show that proposed constituent materials and method of manufacture will produce concrete of required quality.

3101 TRIAL MIXES are to be prepared for testing and approval one month prior to commencing concreting, by third party testing agency approved by the Engineer.

3151 APPROVAL: do not use mixes before submitted information and evidence has been approved. Such approval will not prejudice the requirement that mixes are to comply with the Specification.

3201 MAKE ADJUSTMENTS to percentage of fine aggregate to allow for:

fineness zone of material

workability requirements

bulking of damp sand if measuring by volume.

3301 ENRICHMENT OF MIX: subject to approval the aggregate/cement ratio may be reduced by up to 10% for first layer of concrete in walls. Do not alter water/cement ratio.

3351 CONTROL OF COLOUR: obtain approval before altering proportions or grading of concrete exposed in finished work.

3501 ADMIXTURES: if approved use strictly in accordance with the manufacturer's instructions.

3511 RETARDING WATER REDUCING ADMIXTURES may be used in large volumes of concrete subject to approval and are to be used when instructed by the Engineer and according to manufacturer's instructions.

3521 RETARDING ADMIXTURES may be used in large volumes of concrete subject to approval and are to be used when instructed by the Engineer and according to manufacturer's instructions.

3531 WATER REDUCING ADMIXTURE (PLASTICISER): to be used in the production of all reinforced concrete unless otherwise specified.

3601 CHLORIDE ION CONTENT IN ADMIXTURES is not to exceed 2% by weight of admixture or 0.03% by weight of cement in mix.

3651 TOTAL CHLORIDE CONTENT IN CONCRETE MIX arising from aggregates, water, cement, cementitious additives, admixtures and other sources is not to exceed 0.15% for structural concrete, percentage of chloride ion to cementitious material by weight.

3701 TOTAL SULPHATE CONTENT IN CONCRETE MIX arising from constituents and other sources is not to exceed the lesser of 0.4% by weight of aggregates or 4.0% by weight of cement in mix, inclusive of cementitious additives.

3801 READY MIXED CONCRETE: concrete mixed outside the site and transported to it is to be batched and mixed in accordance with the requirements of ACI 301 and ASTM C94 or BS 8500-1, BS 8500-2, BS EN 206-1.

3901 CYCLOPEAN CONCRETE: soak plums in water prior to incorporation into Class C concrete. Plums are to be evenly placed and comprise maximum 40% of total volume of concrete in position and with minimum cover of 70 mm.

## E11:4 TESTING CONCRETE

4051 GENERALLY: sampling, testing and assessment of compliance are to be as specified and to ASTM C192/C192M, ASTM C31/C31M, ASTM C39/C39M or to BS 12390 unless otherwise specified or approved.

4101 COMPLIANCE TESTING: testing and checking are to be in the presence of or as agreed with the Engineer. Submit results to the Engineer within 2 working days of completion of each test.

4151 TESTING AUTHORITY: testing shall be carried out by an independent testing authority subject to approval of the Engineer.

4201 ATMOSPHERIC THERMOMETER: provide maximum and minimum thermometer in approved position on the site for measuring atmospheric shade temperature.

4251 SOIL THERMOMETER: provide soil thermometer for measuring concrete and ground temperatures.

4301 TEST APPARATUS: keep in good repair until concrete work is completed.

4321 SAMPLES: to ensure adequate quality control of mixes on the site take samples of each mix of concrete from every mixing point in accordance with the recommendations and the requirements of BS 1881, BS EN 12350, BS EN 12504, BS EN 12390-4 or in accordance with ASTM C31/C31M and ASTM C192/C192M.

4401 SAMPLING RATE: take samples for compliance testing of compressive strength for each mix as follows:

initially 4 random samples during each of the first 10 days of using mix

thereafter not less than one sample during each day of using mix.

unless otherwise approved each sample is to represent a volume of not more than 20 m3. Higher rates of sampling and testing may be instructed at: start of work to establish level of quality, during periods of production when quality may be in doubt or during the pouring of column, cantilever and other critical elements. Subject to approval sampling rates may be reduced when high and consistent quality has been established.

4501 WATER/CEMENT RATIO: where works slump testing is specified for assessing compliance with specified free-water/cement ratio, submit results of preliminary tests to establish relationship between the two properties and obtain approval.

4521 SLUMP TESTS: carry out in accordance with ASTM C143 or BS EN 12350-2 for each concrete batch and when test cylinders/cubes are prepared.

4531 COMPRESSIVE STRENGTH TESTING: a minimum of six test cylinders or test cubes if approved are to be made for each sample. Test three at 7 days and three or more at 28 days. The strength at 28 days must not be less than the compressive strength specified for the relevant class of concrete in Clause A201.

4551 RECORDS: indicate on works test records parts of structure represented by samples tested. Keep records on the site.

4601 FAILURE OF CONCRETE MIX: if concrete mix fails to achieve specified criteria or to pass specified tests arrange for design of mixes to be adjusted and tests repeated until mixes are accepted by the Engineer.

4611 FAILURE OF CONCRETE WORK: if workmanship and finished work are not in accordance with specified requirements then the Engineer may require testing of drilled cores and/or loading tests to be carried out on any part of the structure after completion. The Contractor is to arrange for an approved independent testing authority to carry out such required tests. The costs of all such tests and testing shall be borne by the Contractor.

4621 PROCEDURE FOR DRILLING AND TESTING CORES is to comply with ASTM C42/C42M or BS EN 12504-1. Evaluation of adequacy of concrete in area represented by core tests is to comply with ACI 318/318R and ACI 214R or to BS EN 13791.

4631 STATIC LOAD TESTS are to be carried out and evaluated in accordance with the requirements of ACI 318/318R or BS 8110.

4651 ABSORPTION AND PERMEABILITY TESTS:

- ABSORPTION TEST: The absorption of the hardened concrete from the trial mixes for structural grades shall be tested as a measure of the concrete's ability to resist the ingress of aggressive salts. No absorption tests shall be required for blinding or mudmat concrete. Absorption tests shall be done at age 28-days in accordance with modified BS 1881: Part 122. The mean of the corrected absorption figure for each concrete grade shall be calculated and the absorption of the concrete mixes, tested to BS 1881: Part 122, shall be acceptable if the mean absorption is less than 1.5 percent at 30 minutes for reinforced substructure and external concrete.
- BS EN 12390-8 Depth of Penetration shall be carried out as a measure of water permeability on concrete samples of different components of the structure before the mix design or manufacturing method are approved. The tests shall be carried out in accordance with BS EN 12390-8 at age 28 days and the maximum value of penetration shall not exceed 10 mm for reinforced substructure and external concrete.

- ASTM C1202 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration. The chloride permeability of the concrete shall be determined using cores taken from the concrete samples, in accordance with ASTM C1202. The limit of 1000 coulombs shall not be exceeded at 28-days for reinforced substructure and external concrete.
- The concrete will be deemed to comply with the absorption and permeability requirements of this specification if minimum of two test requirements out of the specified absorption and permeability tests are adequately met.
- If the above acceptance criteria are not met, then the concrete trial mix shall be deemed not to comply with the permeability requirements. New concrete trial mixes should be carried out by the Contractor to fully satisfy the required permeability tests.
- If, in the opinion of the Engineer, the concrete that has failed to meet the permeability requirements of this Specification is likely to cause durability problems, three cores shall be cut from the area represented by failed samples for additional BS 1881-122, BS EN 12390 and rapid chloride permeability testing. The actual location shall be decided by the Engineer.
- A sample of three 75 mm diameter cores, 75 mm long, shall be taken from hardened concrete if directed by the Engineer and tested in accordance with Paragraph 4651. Should the permeability of any core exceed the highest approved test result, then the concrete from which it was cut shall be removed. No permeability test shall be required for blinding or mudmat concrete.

# E12 CONCRETING

## E12:A GENERAL

A101 CONCRETE GENERALLY: constituent materials, composition of mixes, production, information to be provided, sampling, testing and compliance are to be in accordance with Section E11 of the Specification.

## MATERIALS AND PRODUCTS

## E12:Y CURING COMPOUNDS

Y105 CURING COMPOUND: is to be an approved liquid membrane forming compound to ASTM C309, Type 1-D, Class A, applied at a rate, in strict accordance with manufacturer instructions, to restrict moisture loss to not more than 0.55 kg/m2 in 72 hours. The product shall be supplied from reputable and certified suppliers, as approved by the Engineer.

## WORKMANSHIP

## E12:1 GENERALLY

1201 LARGE AREAS: submit drawings showing bay sizes and sequence of casting large areas. Plan bay sizes to avoid cracking due to thermal and shrinkage stresses.

1301 POUR RECORDS: record, in an approved form, details of every pour of concrete placed in the permanent works including:

class of concrete

location and date of pour

ambient temperature and concrete temperature at time of placing

moisture content of aggregates

details of mixes, batch numbers and cement batch number

results of tests

location of sample points for test cylinders or test cubes if approved

details of cores.

1311 WEEKLY RECORDS: provide four copies of records each week covering work carried out the preceding week.

1321 MONTHLY RECORDS: provide monthly histograms of all 28 day cylinder/cube strengths and both monthly and accumulative standard deviations and other information which the Engineer may require concerning concrete placed in the permanent works.

1501 TRANSPORT concrete to avoid contamination, segregation or loss of ingredients.

1551 CLEAN transporting equipment immediately after use or whenever cement or aggregate is changed. Remove free water.

## E12:2 PREPARATION OF SURFACES

2201 CLEANING: at time of placing ensure surfaces on which concrete is to be placed are clean with no debris or free water.

2251 INSPECTION: inform the Engineer not less than 24 hours before each pour of concrete to allow inspection of reinforcement and surfaces on which concrete is to be placed.

## E12:3 PLACING AND COMPACTING

3051 TRAFFIC: use suitable stools, walkways and barrow runs for traffic over reinforcement or freshly placed concrete.

3151 TIMING: time elapsing between mixing and placing is to be as short as practicable and in no case longer than 30 minutes for site mixed concrete and 50 minutes for ready mixed concrete.

3201 PLACING: do not discharge concrete through reinforcement or other obstructions to cause uneven dispersal, segregation or loss of ingredients. Use suitable chutes or trunking

to place concrete where reinforcement is congested. Design of chutes or other means of placing is to be submitted for approval. Height of any drop of concrete is not to exceed 1.5m. Place concrete in final position in one continuous operation up to movement and construction joints.

3301 CASTING BAYS: allow not less than 48 hours between casting of adjacent bays separated by construction joints or formed contraction joints.

3351 EXPANSION JOINTS: do not place concrete on both sides of joint at same time unless otherwise approved.

3401 REINSTATE REINFORCEMENT displaced during placing of concrete.

3451 HOT AND ADVERSE WEATHER: do not place concrete:

when ambient shade air temperature exceeds 43 deg. C

during rain, snow or heavy sand storms.

3455 HOT WEATHER: when ambient shade air temperature exceeds 32 deg. C conform with the general requirements of ACI 305R. When ambient shade air temperature is 37 deg. C and rising adopt special procedures during concreting operations to ensure that the concrete temperature when placed does not exceed 35 deg. C. As a minimum:

mixing water: cool to a temperature between 0 deg. C and 15 deg. C by adding ice to the water tank or using a chilled water system. The addition of ice directly to the concrete mix shall be allowed as directed by the Engineer.

aggregates: store under shade and protect from direct sunlight, cool by water sprinkling

formwork and reinforcement: protect from direct sunlight prior to concreting

transit mixers: wrap and secure thermal insulation around drums to avoid over heating of drum metal and excessive heat transfer.

3501 COMPACT CONCRETE by mechanical vibration, unless otherwise approved, to full depth of fresh concrete to ensure full compaction and amalgamation with previous batches. Do not damage adjacent partly hardened concrete. Compact concrete thoroughly around reinforcement, duct formers, inserts and into corners of formwork.

3551 VIBRATORS, except where otherwise agreed by the Engineer, are to be immersion vibrators of adequate size and power operating at a frequency of not less than 6000 cycles per minute. Inform the Engineer of the number and type of vibrators to be used. Maintain vibrators in good working order, use trained and experienced operators and provide standby vibrators. Do not use external vibrators without approval.

## E12:4 CURING AND PROTECTING

4051 CURING: as soon as concrete has set or immediately after striking formwork cover surfaces of concrete as specified. Keep surfaces of concrete continuously covered for not less than 7 days.

4101 METHOD OF COVERING is to be approved and is not to disfigure permanently exposed surfaces or affect satisfactory bond of subsequent coatings. Method of covering, subject to other requirements, is to be by:

retaining forms in position

impervious sheet materials

absorbent materials, kept damp

application of curing compound.

When covering with sheet materials ensure edges are secured throughout specified curing period to prevent draughts passing over surfaces of concrete.

4201 HOT WEATHER: keep newly placed concrete continuously wet for a minimum of fourteen days. Keep curing and protective surface covering continuously saturated with water. Fog spray of water or cover with appropriate material should be used over freshly laid horizontal members, such as slabs to prevent plastic shrinkage.

4251 PROTECTION: prevent damage to concrete as follows:

surfaces generally from rain, wind and sun, indentation and physical damage

surfaces exposed in finished work from rust marks and other disfigurements

immature concrete from physical shock or movement

immature concrete from thermal shock, particularly from cold water.

## E12:5 TESTING OF CONCRETE WATER RETAINING STRUCTURES

5050 GENERAL: Testing of concrete water retaining structures, for water tightness, shall be based on the requirements of ACI 350.1-01. Testing shall be performed after completion of the structure, installation of fittings and accessories, but before the application of internal waterproofing, and before any backfilling behind the structure's walls has taken place.

5101 ALL TANK PENETRATIONS AND OUTLETS shall be securely sealed to prevent loss of water from the tank during the test. Tank penetrations and outlets shall be monitored before and during the test and shall be repaired from leakage (if any) prior to taking test measurements.

5151 RATE OF INITIAL FILLING of a new tank should not exceed 1.2m/hr (of the tank height). Tank filling shall be continued until the water surface is at the design maximum water level or 100 mm below any fixed overflow level, whichever is lower.

5201 TEST MEASUREMENTS shall be recorded at 24 hr intervals. The test period shall be at least the theoretical time required to record a drop in the water surface of 10 mm, which is, according to the acceptance criterion, ($2\times10^4/h$) days, rounded up, where h is the water depth in (mm). Test period need not exceed five consecutive days.

5251 THE CHANGE IN WATER VOLUME in the structure shall be calculated and corrected, if necessary for evaporation, precipitation and temperature. If loss exceeds the required criterion, the structure shall be considered to have failed the test. The structure shall also be considered to have failed the test if observed flowing or seeping from the structure or if moisture can be transferred from exterior surface to a dry hand. The structure shall not be considered to have failed the acceptance criterion if dampness or wetness on top of a footing, in the absence of flowing water, is observed.

5301 ACCEPTANCE CRITERION AND PERFORMANCE OF TEST shall be in accordance with the requirements of ACI 350.1, standard criterion HST-050, which requires that the drop in the water surface not exceed 0.05% in 24 hours.

5351 RETESTING SHALL BE PERMITTED if the first test fails to satisfy the criterion. A second test may be performed immediately following the first test, provided that no visible leakage is exhibited. If the tank fails the second test or if it was not tested immediately after the first test failure, the tank shall only be retested after probable areas of leakage have been detected and repaired. Tanks shall be retested until they meet the required criterion.

E12:6 MASSIVE CONCRETE

When hot weather conditions exist that would impair quality and strength of concrete, place concrete complying with ACI 305R and as specified.

Contractor is responsible for ensuring the following:

Conducting a theoretical simulation prior to casting by taking into consideration all expected conditions during casting process, to ensure that the previously indicated temperature constraints will be satisfied.

Providing insulation through using impervious sheet to warm the concrete surface and prevent cooling of the concrete surface faster than the inner core.

Cover reinforcing steel with water-soaked burlap if it becomes too hot, so that steel temperature will not exceed the ambient air temperature immediately before embedding in concrete.

Fog spray forms, reinforcing steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without puddles or dry areas.

Use water-reducing retarding admixture when required by high temperatures, low humidity, or other adverse placing conditions, as acceptable to Engineer.

Shade mixing plant and trucks, aggregates, water tank, and cement silo.

Paint white the mixing plant, trucks, water tank, and cement silo.

Insulate the water tank and supply piping.

Provide necessary shades over and around the concrete being poured to prevent sun rays from coming into direct contact with the surface of the concrete and the form work for a period of about 7 days (minimum from the time of pouring concrete).

Concrete placing shall be completed as quickly as possible to reduce transit time.

Curing of exported concrete shall be immediately carried out.

# E21 REINFORCEMENT FOR IN SITU CONCRETE

## PRODUCTS

### E21:H BARS

H105 HOT ROLLED MILD STEEL BARS: to BS 4449 Grade 250 or ASTM A615/A615M Grade 40.

H155 DEFORMED HIGH YIELD STEEL BARS: to one of the following:

1. ASTM A615/A615M Grade 60 with maximum Carbon Content of 0.3%.
2. ASTM A 706/A706 M Grade 60.

H205 CERTIFICATES AND DETAILS: provide with each delivery of bar reinforcement:

certificates of origin and of compliance with appropriate standard including the bend and rebend tests

delivery note giving details of each consignment.

H225 TEST RECORDS: provide manufacturer's test records demonstrating compliance with and frequency of testing in accordance with appropriate standard. Records of test results are to include:

tensile strength

0.2% proof stress for bars to BS 4449 and for steel wires to BS 4482

yield stress of bars to BS 4449

percentage elongation and gauge length

cold bend test

rebend test

size of effective cross-sectional area of bar or steel wire

ladle analysis of steel showing chemical composition.

H250 TEST PIECES: when tests verifying compliance with appropriate standard are required deliver test pieces selected by the Engineer to an approved independent laboratory.

H275 INDEPENDENT LABORATORY RESULTS will overrule results given in manufacturer's certificates and the Contractor's test records. Failure of test pieces to comply with the Specification will result in the rejection of correlative bar deliveries from which they were selected.

H305 TAG clearly bundles of reinforcement with bar mark references.

E21:J MESH

J205 WELDED WIRE FABRIC REINFORCEMENT: to BS 4483 or ASTM A185/A185M.

E21:X ACCESSORIES

X405 BAR SUPPORTS, bolsters, chairs, spacers and other devices for spacing, supporting and fastening bar and mesh reinforcement in place are to be steel wire, plastic or precast concrete of greater compressive strength than poured concrete and generally complying with CRSI DA4 "Manual of Standard Practice".

X415 BAR SUPPORTS and cover spacers in contact with forms for concrete surfaces which will be exposed are to be plastic or plastic coated. Use of precast concrete is not permitted.

X455 COVER SPACERS: proprietary pattern to approval.

Man: Betomax Kunsthoff und Metalwarenfabrik GmbH & Co.

Man: Elameen for Plastic

or other equal and approved.

X605 TYING WIRE: 1.6 mm (16 swg) annealed iron wire.

X705 SCREWED COUPLERS for mechanical splices of deformed high yield steel bars are to consist of two seamless steel sleeves and interconnecting high tensile steel stud with plastic protection caps for threaded section of sleeve.

Man: Ancon Building Product

Man: Screwed Couplers
Ref: Dextra

or other equal and approved.

WORKMANSHIP

E21:1 GENERALLY

1051 REJECT consignments of reinforcement showing signs of fracture.

1101 STORE reinforcement clear of ground and prevent contamination by other materials.

1151 PROTECT reinforcement from corrosive effects of humidity, water and dust.

1201 OBTAIN APPROVAL of fixed reinforcement before concrete is placed. Notwithstanding approval by the Engineer correct placing and fixing of reinforcement are the Contractor's responsibility.

1251 CLEANLINESS: at time of placing concrete the reinforcement is to be clean and free from corrosive pitting, loose mill scale, loose rust, ice, oil and other substances adversely affecting reinforcement, concrete or bond between the two.

1301 RUST STAINING: protect projecting reinforcement from weather where rust staining of exposed concrete surfaces may occur.

E21:2 CUTTING AND BENDING

2051 CUTTING AND BENDING SCHEDULES will not be provided. Provide interim detailing necessary to cut and bend reinforcement unless otherwise instructed. Prepare bar bending schedules in accordance with BS 8666 and submit in duplicate to the Engineer at least four weeks prior to placing reinforcement.

2101 BENDING: bend bars cold on approved machines. Do not rebend bars without approval. Hot bend only with approval. Bend bars to shapes shown on the schedule within dimensional tolerances given in BS 8666. Reduce amount of bending at temperatures below 5 deg. C to prevent fracture of steel.

2151 IDENTIFICATION: tie bars together in bundles or groups and legibly label in accordance with BS 8666.

2201 ADJUSTMENTS: provide facilities for hand bending on the site for approved minor adjustments.

2301 PROJECTING REINFORCEMENT: do not bend without approval.

E21:3 FIXING

3051 TOLERANCES: fix reinforcement in position within the following tolerances:

+/-10 mm for ties and stirrups in any direction parallel to a concrete face

+/-40 mm for longitudinal location of bends and ends of bars at continuous ends

+/-10 mm for longitudinal location of bends and ends of bars at discontinuous ends.

3101 LAPS OR SPLICES: obtain instructions if details are not provided.

3151 ELECTROLYTIC ACTION: do not fix or place reinforcement in contact with non-ferrous metals.

3201 SECURE reinforcement with tying wire or approved steel clips. Bend wire well back clear of forms.

3251 TACK WELDING: do not tack weld.

3351 COVER: to be not less than nominal cover shown on the Drawings. Actual concrete cover for reinforcement located in relation to only one face of member (e.g. straight bar in slab) is to be not more than required nominal cover plus:

5 mm on bars not exceeding 12 mm diameter

10 mm on bars over 12 mm and not exceeding 25 mm diameter

15 mm on bars over 25 mm diameter.

3401 BAR SUPPORTS: provide as necessary to space, support and fasten reinforcement in position and agree quantity and arrangement with the Engineer. Fix chairs at 1 m centres to support top reinforcement in slabs unless detailed otherwise. Fix spacers at 1 m centres between wall reinforcement unless detailed otherwise.

3501 COVER SPACERS: obtain approval of type, size and position.

3551 DO NOT insert bars into placed concrete.

3601 FORMS AND FORM LININGS: do not damage when fixing reinforcement.

E21:4 JOINTING

4051 STRUCTURAL WELDED JOINTS: not permitted.

4101 MECHANICAL SPLICES: do not use unless approved.

4102 MECHANICAL SPLICES: on enquiries and orders state the standard of deformed bars to which screwed couplers are to be swaged. Carry out swaging under the supervision of and in accordance with manufacturer's instructions using a press supplied by him.

# E31 FORMWORK FOR IN SITU CONCRETE

## PRODUCTS

### E31:E MOULDS

E105 COFFER MOULDS: glass reinforced plastic (GRP) or polypropylene, internally stiffened to ensure rigidity without undue deflection and with smooth finish for surfaces in contact with concrete.

Man: Atex Building Products Ltd.
Ref: 900 Waffle Mould

Man: Barnes GRP Formwork Ltd.
Ref: Waffle Mould

Man: GKN Mills Ltd.
Ref: 9M Moulds

or other equal and approved.

E205 TROUGH MOULDS: glass reinforced plastic (GRP) or polypropylene, complete with diaphragms, bonded internally to ensure rigidity and with smooth finish for surfaces in contact with concrete.

Man: Atex Building Products Ltd.
Ref: 600 Trough Moulds

Man: Barnes GRP Formwork Ltd.
Ref: Trough Mould

Man: GKN Mills Ltd.
Ref: T Form

or other equal and approved.

### E31:G FILLER BLOCKS

G405 CONCRETE BLOCK PERMANENT FORMWORK: tapered, hollow blocks of the sizes and weights shown on the Drawings, manufactured from cement and aggregates to BS EN 12620 mixed to provide minimum compressive strength not less than 30 kg/cm2 of gross area. Blocks are to be cured with water for 10 consecutive days and not incorporated

into the work before 21 days after manufacture. Special blocks with one closed side face are to be placed at sides of beams supporting reinforced concrete ribs.

## E31:X FORM TIES

X105 FORM TIES: approved factory fabricated, adjustable length, removable or snap-off metal form ties designed to prevent form deflection and prevent spalling of concrete upon removal. Provide units that will leave no metal closer than 50 mm to plane of exposed concrete surface.

## E31:Y RELEASE AGENTS AND SURFACE RETARDERS

Y205 RELEASE AGENTS: non-staining, effective after exposure to high temperature, sun and wind.

Man: Fosroc
Ref: Reebol

Man: Master Builders Technologies
Ref: Rheofinish 202

Man: Sika
Ref: Separol

or other equal and approved.

Y405 SURFACE RETARDERS: liquid application to retard set of surface mortar to controlled appropriate depth.

Man: Feb MBT
Ref: RheoFinish 282 R

Man: Sika
Ref: Rugasol 2

or other equal and approved.

# WORKMANSHIP

## E31:1 DESIGN AND CONSTRUCTION

1051 GENERALLY: provide formwork to produce finished concrete work to required dimensions and finishes.

1101 DETAILS: provide details of forms as follows:

positions and types of construction joints

layout of panel joints where exposed to view

layout of form tie holes where exposed to view

means of sealing panel joints, form tie holes and at construction joints

surface of forms and other means of obtaining required finish

access openings.

1151 SLOPING UPPER SURFACES OF CONCRETE exceeding 30 deg. are to be constructed against formwork. Upper surfaces sloping between 20 and 30 deg. are also to be constructed against formwork unless it can be demonstrated to the satisfaction of the Engineer that such slopes can be achieved using special screed boards to hold concrete in position during vibration. Secure formwork for sloping upper surfaces to prevent uplift due to pressure of concrete.

1201 LOADINGS: design and construct formwork to ACI 347R to avoid high intensity point loads and to withstand:

vertical loads including weight of formwork, reinforcement, concrete and live loads etc.

lateral pressure of concrete

horizontal loads including wind etc.

special loads including impact, uplift, concentrated loads etc.

1211 DECK LOADINGS: advise the Engineer of construction load of each deck. Prop through decks if construction load on particular deck exceeds:

design loading, or

reduced loading agreed with the Engineer for decks cast less than 28 days.

1251 BEARINGS: submit details of proposed prop bearings to the Engineer for checking the effects on structure.

1301 CAMBERS: submit details of proposed cambers to soffits of beams and slabs. Make allowance for deflection of formwork under weight of concrete to achieve agreed cambers.

1321 DEFLECTION: maximum permissible deflection of formwork under loads is not to exceed 3 mm or 1/600 of free span, whichever is less.

1341 DURING CONCRETE PLACING, secure wedges and other adjusting devices against movement and maintain watching to ensure no movement occurs.

1351 KICKERS: to be not less than 150 mm high and cast monolithically with base slab. Provide to all joints unless otherwise instructed or indicated on the Drawings.

1401 JOINTS IN FORMS: construct to prevent loss of grout between joints in form linings and between forms and completed work.

1421 TEMPORARY OPENINGS: provide where necessary in formwork for cleaning and inspection.

1601 FIXING DEVICES: no metal part of any device for securing forms is to remain within specified concrete cover except where agreed by the Engineer. No ties are to pass through concrete members designed to be part of watertight structure. Do not use wire form ties except where agreed by the Engineer.

## E31:2 TREATMENT OF FORM FACES

2051 RELEASE AGENTS: do not apply to reinforcement, hardened concrete or other materials not part of the form face or to permanent forms. Use same type and make throughout entire area of one finish. Apply evenly to the form faces from top downwards and to horizontal surfaces last. Use minimum amount necessary to obtain clean release and prevent excessive local collection.

2101 SURFACE RETARDERS: do not use without approval except to provide key for other finishes or at construction joints.

2151 STEEL FORMWORK: remove loose mill scale and loose rust before placing concrete.

## E31:3 STRIKING

3051 RESPONSIBILITY: notwithstanding other requirements in the Specification or checking or approval by the Engineer safe removal of formwork and supports is the responsibility of the Contractor.

3101 STRIKE formwork without disturbing, damaging or over-loading structure.

3201 RE-USE: clean, make good and store to approval formwork to be re-used. Remove from the site formwork not to be re-used.

3301 RE-PROPPING will be permitted subject to approval.

3351 MINIMUM PERIODS for retaining formwork in position before striking and applicable to ordinary Portland cement concrete without accelerating or retarding admixtures at temperatures above 10 deg. C are as follows:

| | | |
|---|---|---|
| vertical formwork to columns, walls and beams | : | 2 days |
| pan joist forms removed without disturbing formwork or shoring | : | 4 days |
| soffit forms to slabs with spans up to 6 m | : | 10 days |
| soffit forms to slabs with spans over 6 m, to joists, arches and beams | : | 14 days |
| props to slabs with spans up to 6 m | : | 14 days |
| props to slabs with spans over 6 m, to joists, arches and beams | : | 21 days |

Obtain prior approval of minimum periods for striking for mixes using accelerating and retarding admixtures or other types of cement. Notwithstanding the above requirements it is the Contractor's responsibility to delay striking formwork until it can be undertaken and completed without causing damage to concrete.

3401 EARLIER STRIKING of soffit forms to slabs, joists, arches and beams prior to striking props is to be achieved without disturbing props. Do not remove props temporarily and subsequently replace.

## E31:4 FIXING PERMANENT FORMS

4101 FILLER BLOCK ALIGNMENT: keep rows straight using battens, slip tiles or rib spacers as appropriate and approved.

4151 OPEN ENDS OF FILLER BLOCKS: seal by approved method before placing concrete.

# E32 FORMED FINISHES FOR IN SITU CONCRETE

## E32:1 GENERALLY

1101 TOLERANCES for finished concrete work are to be within permissible deviations tabulated in BS 5606.

1111 TOLERANCES for finished concrete work are to be within permissible deviations tabulated in ACI 347R.

1151 CONTROL SAMPLES: prepare control samples using proposed method of construction including plant, formwork, release agent, reinforcement, specified concrete mix and method of obtaining finish. Obtain approval of appearance of each sample before placing concrete represented. Approved samples will be the control standard for subsequent work.

1201 FORMED FINISHES: do not replace parts of formwork panels where this may cause change of colour in concrete exposed in finished work. Do not erect formwork for special finishes generally until reinforcement has been fixed. If this is not possible then protect surface of formwork from becoming dirty or damaged by covering with stout building paper or by other approved method until immediately prior to concreting. Inspect formwork lining or moulds frequently to ensure constant texture. The Engineer will order formwork to be relined or renewed if in his opinion the surface has altered sufficiently to give a different texture or to give rise to a variation in drying out time of concrete. Do not mix new and used boards on same elevation.

1401 FORMWORK TIE HOLES: fill with cement and sand 1:2 mortar to approved sample.

## E32:2 FORMED FINISHES

### E32:21 BASIC FINISH

2121 GENERAL REQUIREMENTS: none except for tolerances and full compaction. Produce finish with sawn boards, sheet metal or other material preventing loss of fine material from concrete being placed. Use for areas not exposed in finished work.

## E32:22 COFFERED AND TROUGHED FINISHES

2211 CONTROL SAMPLE: provide sample panel size 1.25 m x 1.25 m.

2231 GENERAL REQUIREMENTS:

comply with recommendations of mould unit manufacturer

blowholes less than 5 mm in diameter will be permitted but otherwise surface is to be free from voids, honey- combing and other defects

do not use concrete cover spacers without approval.

2241 MAKING GOOD: finish is to be left as struck. Making good small defects may be permitted but only after inspection and approval. Submit proposed methods of executing remedial works for approval.

## E32:23 PLAIN (FAIRFACE) FINISH

2311 CONTROL SAMPLE: provide sample panel size 1.25 m x 1.25 m.

2321 GENERAL REQUIREMENTS:

produce even finish with sheet material (e.g. plywood)

arrange panels in regular pattern as surface feature unless otherwise shown

blowholes less than 10 mm in diameter will be permitted otherwise surface is to be free from voids, honeycombing and other large defects

variation in colour resulting from use of impermeable form lining will be permitted but surface is to be free from discolouration due to contamination or grout leakage

do not use concrete cover spacers without approval.

2331 TOLERANCES:

abrupt irregularities: not allowed

gradual irregularities expressed as maximum permissible deviation from a 1 m straight edge: 5 mm.

2341 ARRISES are to have 20 x 20 mm chamfer unless otherwise shown.

2351 MAKING GOOD: finish is to be left as struck. Making good small defects will normally be permitted but only after inspection and approval. Submit proposed methods of executing remedial works for approval.

2371 BLOWHOLES: fill with mortar to approved sample.

E32:24 FINE FINISH

2401 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&fine-sample&

2402 PRICING SAMPLE: required finish differs from pricing sample as follows:

&fine-differs&

2411 CONTROL SAMPLE: provide sample panel size 1.25 m x 1.25 m.

2421 GENERAL REQUIREMENTS:

produce smooth even finish with impervious sheet material (e.g. plastics faced plywood/steel sheet/glass reinforced plastic)

make panels as large as practicable and arrange in approved regular pattern as feature of surface

blowholes less than 5 mm in diameter will be permitted but otherwise surface is to be free from voids, honey- combing, fins, projections and other defects

variation in colour resulting from use of impermeable form lining will be permitted but surface is to be free from discolouration due to contamination or grout leakage

do not use concrete cover spacers without approval.

2431 TOLERANCES:

abrupt irregularities: not allowed

gradual irregularities expressed as maximum permissible deviation from a 1 m straight edge: 3 mm.

2441 ARRISES: to have 20 x 20 mm chamfer unless otherwise shown.

2451 INTERSECTING FLUSH SURFACES horizontally or vertically between columns and beams or other structural members are to be separated by 20 x 20 mm grooves unless otherwise shown.

2461 MAKING GOOD: finish is to be left as struck. Making good small defects may be permitted but only after inspection and approval. Submit proposed methods of executing remedial works for approval.

2471 BLOWHOLES: fill with mortar to approved sample and rub down to the satisfaction of the Engineer.

E32:25 ROUGH BOARD FINISH

2501 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&board-sample&

2502 PRICING SAMPLE: required finish differs from pricing sample as follows:

&board-differs&

2511 CONTROL SAMPLE: provide sample panel size 1.25 m x 1.25 m.

2521 GENERAL REQUIREMENTS:

form or form lining is to consist of approved rough textured timber boards seasoned to a moisture content of not more than 25% and not less than 18%

arrange boards of varying textures to give uniform overall effect

assemble boards to prevent penetration of grout

soak pre-assembled forms with clean water before erecting and keep damp until concrete is placed

obtain approval for use and type of release agent

do not use cover spacers without approval.

2541 ARRISES: to have 20 x 20 mm chamfer unless otherwise shown.

2561 MAKING GOOD: finish is to be left as struck. Making good small defects may be permitted but only after inspection and approval. Submit proposed methods of executing remedial works for approval.

2571 DEFECTS: if making good is permitted fill with matching mortar using sponge rubber faced float to approved sample.

E32:26 RIBBED FINISH

2601 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&rib-sample&

2602 PRICING SAMPLE: required finish differs from pricing sample as follows:

&rib-differs&

2611 CONTROL SAMPLE: provide sample panel size 1.25 m x 1.25 m.

2621 GENERAL REQUIREMENTS:

form or form lining is to consist of approved timber battens fixed to plywood

battens are to have clean, sharp arrises and are to be stopped at base with waterproof filler to prevent penetration of grout and sanded to give a smooth surface

plywood is to be bonded with type WBP adhesive to BS 1203

forms not treated with impermeable coating are to be soaked with clean water before erection and kept damp until concrete is placed

use approved release agent

do not use cover spacers.

2631 FIX BATTENS securely to plywood backing with adhesive and screws to prevent penetration of grout.

2661 MAKING GOOD: finish is to be left as struck. Making good small defects may be permitted but only after inspection and approval. Submit proposed methods of executing remedial works for approval.

# E33 WORKED FINISHES FOR IN SITU CONCRETE

## E33:1 GENERALLY

1101 TOLERANCES for finished concrete work are to be within permissible deviations tabulated in BS 5606.

1111 TOLERANCES for finished concrete work are to be within permissible deviations tabulated in ACI 347R.

1151 CONTROL SAMPLES: prepare control samples using proposed method of construction including plant, formwork, release agent, reinforcement, specified concrete mix and method of obtaining finish. Obtain approval of appearance of each sample before placing concrete represented. Approved samples will be the control standard for subsequent work.

1301 PLASTIC CONCRETE: do not wet surface of concrete to assist surface working.

1351 WORKED FINISHES: protect adjacent work from damage.

## E33:3 WORKED FINISHES TO PLASTIC CONCRETE

### E33:31 TAMPED FINISH

3121 TAMP surface with edge of board or beam to give even texture of parallel ribs.

### E33:32 SCORED FINISH

3201 PRICING SAMPLE: a similar type and quality of finish can be inspected at:

&scored-sample&

3202 PRICING SAMPLE: required finish differs from pricing sample as follows:

&scored-differs&

3211 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

3221 SCORING: scratch surface with &scoring-method& to give slightly roughened even texture.

E33:33 FLOATED FINISH

3311 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

3321 FLOATING: use &float-method& to give even texture with no ridges or steps.

E33:34 TROWELLED FINISH

3401 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&trowel-sample&

3402 PRICING SAMPLE: required finish differs from pricing sample as follows:

&trowel-differs&

3411 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

3441 INITIAL FINISH: produce floated finish:

without excessive working

with closed smooth surface with no ridges or steps

with gradual irregularities expressed as maximum permissible deviation from:

3 m straight edge: 6 mm

1 m straight edge: 2 mm.

3451 TROWELLING: produce uniform smooth surface free from trowel marks and other blemishes by successive trowellings using either:

hand trowel, scraping off surplus weak mortar and applying sufficient pressure to close surface, or

power trowel.

## E33:4 WORKED FINISHES TO HARDENED CONCRETE

### E33:41 ABRASIVE BLASTED FINISH

4101 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&blast-sample&

4102 PRICING SAMPLE: required finish differs from pricing sample as follows:

&blast-differs&

4111 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

4121 CATALOGUES for blasting equipment are to be submitted for approval before casting concrete.

4131 PROTECTIVE CLOTHING as recommended by equipment manufacturer and approved by the Engineer is to be worn by operatives.

4141 INITIAL FINISH: surfaces are to have approved initial finish before abrasive blasting is carried out.

4151 TIMING: carry out abrasive blasting within seven days of striking formwork.

4161 BLAST surface with abrasive to even texture and average depth of exposure all to approval and in accordance with samples. Begin at top, direct nozzle from side to side and keep at a distance approximately 300 mm from surface.

E33:42 TOOLED FINISH

4201 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&tool-sample&

4202 PRICING SAMPLE: required finish differs from pricing sample as follows:

&tool-differs&

4211 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

4231 INITIAL FINISH: surfaces are to have approved initial finish before tooling is carried out.

4241 TIMING: concrete is to be not less than 21 days old when tooling is carried out.

4251 TOOL using rotary head or kango hammer removing least thickness of material to expose aggregate. Normal thickness removed is to be approximately 3 mm. Move bush hammering tool from side to side over a range of about 150 mm while rotating bush hammer disc through a 45 degree arc. To avoid noticeable change in texture each surface is to be dressed with a new sharp disc or with one that is partially worn.

E33:43 BRUSH AND WASH FINISH

4301 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&brush-sample&

4302 PRICING SAMPLE: required finish differs from pricing sample as follows:

&brush-differs&

4311 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

4321 INITIAL FINISH: surfaces are to have approved initial finish before brushing and washing is carried out.

4331 TIMING: commence brushing and washing within 18 hours of casting concrete when surface retarder has not been used and dependent upon weather conditions. On no account must treatment be delayed after striking formwork.

4341 BRUSH AND WASH: use either stiff bristle or wire brushes with sufficient water to remove matrix and clean each piece of exposed aggregate. Alternative systems may be used subject to approval. Expose aggregate to 10 mm depth. Commence exposure at perimeter of panels leaving 15 mm wide margin between chamfered edge of panel and line of exposed aggregate finish.

## E33:44 POWER GROUND FLOOR FINISH

4401 PRICING SAMPLE: a similar type and quality of finish can be inspected:

&ground-sample&

4402 PRICING SAMPLE: required finish differs from pricing sample as follows:

&ground-differs&

4411 CONTROL SAMPLE: construct part of finished work in advance of remainder in an approved location minimum size 1.25 m x 1.25 m.

4421 INITIAL FINISH: produce floated finish:

without excessive working

with closed smooth surface with no ridges or steps

with gradual irregularities expressed as maximum permissible deviation from:

3 m straight edge: 6 mm

1 m straight edge: 2 mm.

4431 POWER GRINDING: produce uniform finish:

when concrete is sufficiently hard for sand particles not to be torn from surfaces

with minimum of grinding necessary to remove surface laitance

with even glass paper texture, free from blemishes

after grinding sweep away dust and thoroughly wash down.

# E41 JOINTS IN IN-SITU CONCRETE

## PRODUCTS

### E41:H SECTIONS

H105 PVC WATER BARS: extruded PVC, heavy duty, of the types and sizes shown on the Drawings, and complete with factory fabricated junction pieces.

Man: Fosroc

Man: Servicised

Man: Sika

or other equal and approved.

H115 RUBBER WATER BARS: of the types and sizes shown on the Drawings, hardness 60 to 70 IRHD, tensile strength not less than 20 N/mm2, elongation at break not less than 450%, web thickness varying between 6 and 10 mm according to length and complete with factory fabricated junction pieces.

Man: Fosroc

Man: Servicised

or other equal and approved.

### E41:R RIGID SHEETS

R205 MOVEMENT JOINT SHEET MATERIAL FILLER for expansion joints, unless otherwise specified, is to be bitumen impregnated fibreboard to ASTM D1751 or as manufactured by:

Man: Fosroc
Ref: Bitucell

Man: Servicised
Ref: Aerofil

or other equal and approved.

R225 MOVEMENT JOINT SHEET MATERIAL FILLER for expansion joints in water retaining structures is to be bonded granular cork to ASTM D1752 or as manufactured by:

Man: Fosroc
Ref: Hydrocell XL

Man: Servicised
Ref: Korkpak, Resin Bonded Cork

or other equal and approved.

## E41:X ACCESSORIES

X105 DOWEL BARS: mild steel, to BS 4449, Grade 250 or ASTM A615/615M Grade 40, perfectly straight, with sawn (not sheared) ends.

X155 COMPRESSIBLE CAPS for dowel bars are to be approved type incorporating not less than 20 mm of compressible material.

## E41:Y JOINT SEALANTS

Y305 CONCEALED JOINT SEALANT for movement joints is to be oil based mastic compound unless otherwise specified.

Man: Fosroc
Ref: Secomastic

or other equal and approved.

Y350 EXPOSED JOINT SEALANT for movement joints unless otherwise specified, is to be an approved polysulphide rubber based compound unless otherwise specified.

Man: Fosroc
Ref: Thioflex 600

or other equal and approved.

Y405 JOINT SEALANT for movement joints in water retaining structures is to be polysulphide based compound to BS EN ISO 11600 or as manufactured by:

Man: Fosroc
Ref: Thioflex 600

Man: Servicised
Ref: Paraseal

or other equal and approved.

Y425 JOINT SEALANT for movement joints in swimming pools is to be polysulphide based compound to BS EN ISO 11600 or as manufactured by:

Man: Servicised
Ref: Vertiseal

or other equal and approved.

Y445 JOINT SEALANT for movement joints in sewage treatment works is to be compound of chemically resistant elastomeric polymers.

Man Servicised
Ref: Vertigard

or other equal and approved.

Y465 JOINT SEALANT for movement joints in retaining walls and basements is to be bitumen based compound.

Man: Fosroc
Ref: Plastiseal

Man: Servicised
Ref: Servijoint

or other equal and approved.

Y485 JOINT SEALANT for movement joints in drinking water reservoirs and for damp conditions is to be sulphate resistant polymeric compound for use with cement.

Man: Servicised
Ref: Servigard

or other equal and approved.

Y505 BACKING STRIPS, bond breakers and primers are to be types recommended by joint sealant manufacturer for particular purpose.

WORKMANSHIP

## E41:1 MOVEMENT AND CONSTRUCTION JOINTS

1051 GENERALLY: joints are to be:

straight, vertical, horizontal or as detailed or approved

formed to accommodate projecting reinforcement.

1201 MOVEMENT JOINTS are defined as:

formed expansion joints

formed contraction joints

induced contraction joints.

1251 FORMED MOVEMENT JOINTS: construct rigid stop ends and formwork at formed movement joints to permit separate construction of structurally separate parts of the work.

1301 CONSTRUCTION JOINTS: where not coincident with movement joints submit proposals for positions of construction joints and obtain approval.

1302 CONSTRUCTION JOINTS: lightly roughen face to expose coarse aggregate unless otherwise instructed. Wet and cover with 1:1 cement and sand grout immediately prior to placing fresh concrete. Stop roughening 25 mm from arrises to surfaces exposed to view in finished work. Remove small mortar lips from exposed arrises with carborundum stone. Face is to be clean and damp before fresh concrete is placed against it.

1351 CONCRETE FLOORS: side and end forms are to be square edged with steel top surface.

1401 WATERBARS: install at construction joints to form a continuous diaphragm. Install in longest lengths practicable. Fix and support water bars and fabricate joints in accordance with manufacturer instructions. Secure and protect during progress of concreting operations.

1402 PVC WATERBARS: when instructed by the Engineer, test site welded joints for watertightness and strength in accordance with U.S. Corps of Engineers Method CRD-C572, spark test.

1501 DOWEL BARS: coat half of each bar with approved proprietary debonding compound or fit with approved plastic sleeve. Fix bars securely at required level, perfectly level, at right angles to and centred on the joint. Fit compressible caps to debonded ends of bars.

1601 SEALING OF MOVEMENT JOINTS: preparation and application is to be strictly as manufacturer's recommendations. Joints are to be thoroughly clean and dry, free from oil and loose material. Vigorously wire brush or grit blast the joint faces and clean out with compressed air. Prime faces of joint and allow to dry. Where exposed to view mask edges of joint with tape before priming and remove immediately after sealing. Apply sealant ensuring maximum adhesion to sides of joint and a neat, smooth and clean finish.

# E71 DAMP-PROOF MEMBRANES AND COATINGS

## PRODUCTS

### E71:L FLEXIBLE SHEETS

L410 POLYTHENE SHEET: 1200 gauge, (0.3 mm) damp-proof membrane.

Man: Visqueen Films Ltd
Ref: Visqueen 1200

or other equal and approved.

L610 SELF-ADHESIVE POLYETHYLENE SHEET: cold applied, flexible, preformed waterproofing membrane comprising: a high density multi-layer polyethylene film with a self-adhesive rubber/bitumen compound, and having the following minimum properties:

total thickness : 1.5 mm

weight : 1.6 kg/m2

tensile strength : 42 N/mm2

elongation : 210% longitudinal; 160% transversal

tear resistance : 340 N/mm longitudinal; 310 N/mm transversal

puncture resistance : 220 N 65 mm

Man: Servicised
Ref: Bitu-thene 3000

or other equal and approved.

L810 PRIMERS, BONDING COMPOUNDS, ADHESIVES and the like are to be types recommended by sheet manufacturer for particular purpose.

### E71:V COATING MATERIALS

V710 COLD APPLIED BITUMINOUS COATING SOLUTION: to BS 3416, Type 1 or ASTM D449, Type 1 or as manufactured by:

Man: Fosroc
Ref: Nitoproof 100

Man: Master Builders Technologies
Ref: Masterseal 410.

or other equal and approved.

V820 CHEMICAL WATERPROOF COATING: surface-applied material that causes capillary waterproofing system to protect concrete in-depth.

Man: Xypex Chemical Corporation
Ref: Xypex

Man: Vandex International Ltd.
Ref: Vandex Super, Vandex Premix

Man: Master Builders Technologies
Ref: Masterseal 501/502.

or other equal and approved.

V910 PRIMERS and the like are to be types recommended by coating manufacturer for particular purpose.

E71:X ACCESSORIES

X105 GENERALLY: types recommended by sheet or coating manufacturer for particular purpose.

X215 ANGLE FILLETS: self adhesive preformed triangular PVC extrusion or other type recommended by sheet or coating manufacturer.

X305 MEMBRANE PROTECTION: approved waterproof and rot-proof protection boards or other alternative means of protection as indicated or recommended by sheet manufacturer.

Man: Servicised
Ref: Servipak

Man: Cartonal
Ref: Cartonal Protection Boards

or other equal and approved.

WORKMANSHIP

E71:1 FIXING SHEET MEMBRANES

1101 GENERALLY: ensure holes, cracks, defective joints and other defects in surfaces to be covered are made good. Remove dirt, grease, rust and loose material.

1121 MANUFACTURER'S RECOMMENDATIONS: to be strictly followed. Apply sheets to clean, dry surfaces with joints sealed to give completely waterproof continuous membrane.

1151 PRIMERS: apply by mopping, brushing or spraying to achieve an even and full cover of the surface. Allow to dry before covering.

1201 POLYTHENE SHEET: ensure sheets are clean and dry. Lay single layer loose on base, lap edges 150 mm and seal with adhesive tape.

1251 SELF-ADHESIVE POLYETHYLENE SHEET: prime base and fix angle fillets and accessories; apply membrane adhesive side down, smoothing out and rolling to exclude air and ensure good adhesion between sheets. Lap sides and ends and reinforce with multiple thicknesses of membrane at joints and angles, all in accordance with manufacturer's instructions.

1601 PIPES ETC.: where pipes etc. pass through sheeting make junctions completely watertight by forming collars fully bonded or sealed to both pipes and sheeting.

1601 PIPES ETC.: where pipes etc. pass through sheeting make junctions completely watertight by forming collars fully bonded or sealed to both pipes and sheeting.

1701 INSPECTION: inform the Engineer a reasonable length of time before covering any part of membrane with overlying construction to allow inspection.

1751 PROTECT finished sheeting and prevent puncturing during following work. Cover sheeting with permanent overlying construction as soon as possible.
Immediately prior to covering, check for damage and repair as necessary.

1801 MEMBRANE PROTECTION: cover membrane against which backfill material will be placed with protection boards. Provide temporary support as necessary to ensure boards remain fully in contact with membrane during backfilling operations.

## E71:2 APPLICATION OF COATINGS

2051 GENERALLY: ensure holes, cracks, defective joints and other defects in surfaces to be coated have been made good. Remove dirt, grease, rust and loose material.

2101 DRY SURFACES: dampen before applying water based bitumen emulsion.

2251 APPLY COATINGS GENERALLY in accordance with manufacturer's recommendations to clean, dry surfaces, in dry atmospheric conditions, after primer has dried and after previous coats have hardened.

2301 VENTILATION: spaces in which coatings are to be applied are to be well ventilated.

2401 COLD APPLIED BITUMINOUS SOLUTION OR COMPOUNDS: apply number of coats to thickness and at rate of application as recommended by solution or coating manufacturer for particular purpose.

2451 CHEMICAL WATERPROOF COATING: Number of coats and rate of application should be as recommended by manufacturer for particular purpose.

2551 BRUSHING: work coating into recesses, edges, joints, intersections and over surfaces generally to obtain uniform and continuous film.

2601 SPRAYING: apply coating with spray gun recommended by coating manufacturer covering recesses, edges, joints, intersections and over surfaces generally to obtain uniform and continuous film.

2701 INTERSECTIONS: ensure continuity of coatings including at junctions with other membranes.

2801 COVERING: final covering is to be laid/applied as soon as possible after coating has hardened.

# F STRUCTURAL FRAMING

## F11 STRUCTURAL STEELWORK

### F11:A GENERAL

A111 DESIGN of structural steelwork is in accordance with:

AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings -2005

BS 449: Part 2, Specification for the Use of Structural Steel in Building.

BS 5950: Part 1, Structural Use of Steelwork in Building.

A151 DRAWINGS: provide co-ordination, fabrication and erection drawings and other information showing such details of the work as the Engineer may reasonably require. Drawings and information are to include, but are not limited to, the following:

design calculations

connections not detailed on the Drawings

methods of erection and calculation of erection stresses

methods of bracing and temporary guys.

A201 FABRICATOR AND ERECTOR: submit prior approval by the Engineer the names of proposed fabricator and erector with reference to structural steelwork of a similar nature carried out by them on other projects together with relevant dates and any other information required by the Engineer.

A301 MARKING: obtain approval for proposed methods of identifying and documenting products.

A351 DELIVERY: manufactured items are to be delivered in original packages, containers etc. bearing name of manufacturer and brand. Each piece of material is to bear the official grade and trade mark of the association under whose rules it is graded or is to be accompanied by a certificate of inspection issued by that association.

A401 STORAGE: stack steel off the ground on timber packings and distribute to avoid overloading of areas on which it is stored. Store materials and manufactured items in an

approved manner and protect from exposure to weather and dampness during transit to and after delivery to site.

A451 PROTECTION: during and after erection protect structural steelwork by approved adequate measures from constructional hazards.

PRODUCTS

F11:H SECTIONS

H210 HOT-ROLLED STEEL SECTIONS AND PLATES: are to be to ASTM A36/A36M, having a yield stress of 245 MPa; or to ASTM A572/A572M, Grade 50, having a yield stress of 345 MPa; or equal.

H211 STRUCTURAL STEEL SHAPES, PLATES AND BARS: are to be to ASTM A36/A36M having a yield stress of 245 MPa; or to ASTM A572/A572M, Grade 50, having a yield stress of 345 MPa; or equal.

H220 STRUCTURAL STEEL HOLLOW SQUARE AND RECTANGULAR SECTIONS: are to be to ASTM A501 with a minimum yield stress of 245 MPa; or ASTM A500 Grade “C” having a yield stress of 345 N/mm2 or equal.

H221 STRUCTURAL STEEL HOLLOW CIRCULAR SECTIONS: are to be to ASTM A53 GRADE B having a minimum yield stress of 245 MPa; or ASTM A618, Grade III, having a minimum yield stress of 345 N/mm2 or equal.

H310 COLD-ROLLED STEEL Z AND C SECTIONS: to be to ASTM A653/A653M, Grade A, Type 150 and ASTM A924/A924M, having a minimum yield stress of 345 MPa; or equal, and shall be galvanized to satisfy the specified life to first maintenance.

H311 PURLINS AND GIRTS shall be cold formed, pre-hot dipped galvanized steel Z35 to BS EN 10143, to satisfy the specified first life to maintenance, and having a minimum yield stress of 345 MPa; or equal.

H410 MILL TEST REPORTS: provide triplicate copies of certified mill test reports or certified reports of tests, made by the fabricator in accordance with ASTM A6/A6M or A568/A568M, on steel sections and plates.

## F11:X BOLTS, NUTS AND ELECTRODES

X210 BLACK BOLTS, SCREWS AND NUTS: to ASTM A307 black hexagon bolts and nuts, or DIN 7990 grade 4.6.

X220 ISO METRIC BLACK STEEL HEXAGON BOLTS, SCREWS AND NUTS: Grade 4.6, as specified in BS 4190.

X225 ISO METRIC PRECISION HEXAGON BOLTS, SCREWS AND NUTS: Grade 8.8, as specified in BS 3692.

X250 HIGH STRENGTH FRICTION GRIP (HSFG) BOLTS and associated nuts and washers are to be to ASTM A490 or DIN EN 14399-4, Grade 10.9

X251 HIGH STRENGTH FRICTION GRIP BOLTS and associated nuts and washers are to be as specified in BS EN 14399-1, BS EN 14399-2, BS EN 14399-3, BS EN 14399-4, BS EN 14399-5, BS EN 14399-6, BS EN 14399-7, BS EN 14399-8, BS EN 14399-9, BS EN 14399-10 (General Grade) and in BS 4604: Part 1 (General Grade); or Part 2 (Higher Grade, Parallel Shank).

X260 DIRECT TENSION INDICATOR WASHERS: as per ASTM F959, or equivalent; are to be used at all slip critical bolts.

X415 ANCHOR BOLTS AND NUTS: anchor bolts are to be ASTM F1554 Grade 36 or Grade 55 or Grade 105. Nuts and threads are to be to ASTM A307.

X420 ANCHOR RODS: Grade 4.6 as specified in BS 4190.

X510 STUDS (FOR COMPOSITE ACTION): to AWS D1.1, type B, minimum yield strength 345 MPa at 0.2% offset, made from steel to ASTM A108, with mechanical properties to ASTM A370, and applied in accordance with Recommended Practices for Stud Welding.

X615 METAL-ARC WELDING ELECTRODES: to AWS series of the Specification for Mild Steel Covered Arc-Welding Electrodes, AWS A5.1/A5.1M latest edition or the Specification for Low-Alloy Steel Covered Arc-Welding Electrodes, AWS A5.5/A5.5M latest edition.

X620 BARE ELECTRODES AND GRANULAR FLUX used in the submerged-arc process are to conform to AWS flux classifications of the Specification for Base Mild Steel Electrodes and Fluxes for Submerged Arc Welding, AWS A5.17/A5.17M, or AWS A5.23/A5.23M, latest edition.

X710 MILL TEST REPORTS: provide triplicate copies of certified mill test reports for steel bolts and electrodes to be used in the work. No fabrication work is to commence before approval of test reports.

F11:Y GROUTS

Y105 NON-SHRINK RHEOPLASTIC EXPANSIVE CEMENT GROUT: free flowing, non-shrink, non-ferrous rheoplastic, oil resistant and water resistant; complying with CE-CRD-C621, and having minimum compressive strength of 60 MPa; or equal.

WORKMANSHIP

F11:1 FABRICATION GENERALLY

1060 GENERAL: fabricate steelwork to AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings. Structural steel is to be fully shop fabricated in accordance with the Drawings, and site measurements.

1060 GENERAL: fabricate steelwork to BS 5950. Structural steel is to be fully shop fabricated in accordance with the Drawings, and site measurements.

1081 SHOP INSPECTION: materials and workmanship are subject to inspection and test by the Engineer, who is to have access at all times to all parts of the workshop where steelwork is being fabricated and is to be provided with reasonable inspection facilities.

1101 STARTING: obtain permission of the Engineer before starting fabrication.

1121 HOLES: provide all holes in steelwork required by other trades.

1151 TOLERANCES: fabricate steel in compliance with the requirements of erection tolerances, AWS D1.1 or the American Institute of Steel Construction 9$^{th}$ Edition whichever is more stringent.

1201 MANUAL CUTTING: obtain approval for thermal cutting by hand. If approved, gas cutting is to be carried out in accordance with the AWS Code for Arc and Gas Welding in Building Construction.

1251 THERMAL CUTTING: machine the edges of plate cut by flame which will be subject to dynamic or fatigue loading or liable to brittle fracture. Amount of metal removed is to be to the satisfaction of the Engineer.

1351 COMPRESSION MEMBERS: prepare ends of compression members at splices, caps or bases which are dependent on contact for transmission of compressive stress so that butting faces are in contact over an area sufficient to transmit full load without exceeding permitted stress in bearing.

1401 BEARING STIFFENERS: cut and grind angles and flats to ensure a tight fit along edges in contact with flanges.

1451 BASE PLATES: make 25 mm diameter holes in base plates more than 1 m2 in area to allow escape of air when grouting after erection of columns.

1521 SEALED HOLLOW SECTIONS: ensure insides of sections are dry and clear of debris before sealing ends and openings.

1551 CLEANING: remove burrs and sharp arrisses by grinding.

1601 SHOP ASSEMBLY: check fit, profile and camber before making connections in lattice girders and trusses which are assembled before delivery to site.

1701 TRIAL ASSEMBLIES: make trial assemblies of parts of structure when specified.

1751 MARKING: prepare a marking drawing and mark all steel to indicate position in structure and to assist erection.

F11:2 WELDING

2051 GENERAL: welding is to be to the applicable provisions of AWS D1.1/AWS D1.1M Structural Welding Code, unless otherwise specified.

2101 SITE WELDING: unless otherwise indicated on the Drawings site welding will only be permitted for minor connections subject to written approval by the Engineer.

2351 WELDS: do not place any welds, except those shown on the Drawings, without approval even for temporary attachment and repair of faulty plates.

2451 BUTT WELDS: use run on and run off plates to ensure full throat thickness at ends of butt welds as follows:

material for plates is to be identical to material being welded

prepare plates in same manner as parts being joined

after completion of welding remove plates and grind surfaces of joined parts where plates are attached to make smooth

retain and identify plates for inspection when requested.

2531 WELDERS: provide evidence of each welder's competence to undertake specified work. Welders must have been tested to AWS using same electrodes class and welding positions which will be used in the work.

2541 WELDERS: provide evidence of each welder's competence to undertake specified work. Welders must have been tested to the applicable provisions of AWS D1.1 Structural Welding Code using same electrodes class and welding positions which will be used in the work. Test welders when instructed using:

thickest plate specified and/or

material with highest carbon content

electrodes of appropriate class

welding positions which will be used in the work.

2591 SPECIAL WELDING: test welder's competence to undertake special welding procedures when instructed.

F11:3 BOLTING

3060 GENERAL: unless otherwise specified, make bolted connections in accordance with the AISC Specification for the Design, Fabrication and Erection of Structural Steel for Buildings.

3061 GENERAL: unless otherwise specified, make bolted connections in accordance with BS 5950, and BS 4190, BS 3692, BS EN 14399-1, BS EN 14399-2, BS EN 14399-3, BS EN 14399-4, BS EN 14399-5, BS EN 14399-6, BS EN 14399-7, BS EN 14399-8, BS EN 14399-9, BS EN 14399-10 and BS 4604, as applicable.

3151 HOLES:

do not distort or enlarge holes when using drifts

do not use drifts of larger diameter than holes

report any misalignment of holes

reaming of holes will not be allowed except for minor connections and subject to written approval.

3270 HSFG BOLTS:

use in accordance with ASTM A107 and ASTM A490

place washer under part being turned

Submit for approval method statement for torque tightening.

3271 HSFG BOLTS:

use in accordance with BS EN 14399-1, BS EN 14399-2, BS EN 14399-3, BS EN 14399-4, BS EN 14399-5, BS EN 14399-6, BS EN 14399-7, BS EN 14399-8, BS EN 14399-9, BS EN 14399-10 and BS 4604

place washer under part being turned

Submit for approval method statement for torque tightening.

3401 WASHERS: place under nuts of black bolts.

3402 WASHERS: place under heads and nuts of all bolts connecting metal coated steel.

3451 TAPER WASHERS: place taper washers under bolt heads and nuts bearing on surfaces sloping at 3 degrees or more from a plane at right angles to bolt axis.

## F11:4 ERECTING ON SITE

4011 GENERAL: submit erection programme and method for approval.

4021 EQUIPMENT: suitability and capacity of plant and equipment used for erection are to be to the satisfaction of the Engineer. Equipment is to be in first class working order.

4051 STARTING: obtain permission before starting erection of steelwork.

4061 ANCHORAGES AND TEMPLATES: anchor bolts, templates and other inserts to be built into concrete are to be furnished in ample time for installation without delaying progress of the work.

4071 FOUNDATIONS: before starting erection inspect foundations for line and level, anchor bolts for position, protruding length, condition and slackness.

4081 DEFECTS: inform the Engineer of any defects due to detailing or fabrication errors and obtain approval of methods of rectification before starting remedial works.

4091 DAMAGED MANUFACTURED ITEMS are not to be used in the work. Manufactured items damaged after installation are to be removed and replaced to the entire satisfaction of the Engineer at the Contractor's expense.

4101 ERECTION STRESSES: do not distort steelwork and do not exceed limiting stresses specified in AISC during erection.

4121 ERECTION BRACING: supply erection bracing necessary to ensure complete stability during construction. Remove when safe to do so subject to approval.

4151 CUTTING EQUIPMENT: do not use thermal cutting equipment on site without approval.

4171 WELDING EQUIPMENT: do not use welding equipment on site without approval.

4190 TOLERANCES: erect steel in compliance with the requirements of AISC or AWS-D1.1, whichever is more stringent.

4191 TOLERANCES: erect steel in compliance with the requirements of BS 5950 or AWS-D1.1, whichever is more stringent.

4231 MOVEMENT JOINTS: ensure bolts are in centre of slotted holes after erection of structure.

4241 PROPRIETARY JOINTS: treat sliding surfaces of proprietary joints in accordance with manufacturer's recommendations before connecting.

4251 BASES:

raise or lower to correct level using sawn steel packs not larger than necessary for the purpose

notify the Engineer when space beneath any column base is less than 10 mm or more than 50 mm.

4252 BASES: fill space beneath base plates with approved non- shrink grout by pump or pouring into position against clean and sound surfaces in accordance with manufacturer's instructions.

## F11:5 TESTING

5011 LAMINATION TESTS: carry out ultrasonic testing for lamination on all head plates for moment connections (15 mm thick or above) in accordance with ASTM E164, or DIN EN 12223.

5021 WELD TESTS: carry out visual inspection on all welds. Perform non-destructive testing on a representative sample of at least 10 percent of all weld lengths, initially. If, in the opinion of the Engineer, initial test results are unsatisfactory, the Engineer may extend the scope of weld sampling and testing, which shall be undertaken at the Contractor's own expense. The Engineer may also instruct the Contractor to replace any individual or all welders. Selection of all test samples shall be subject to approval by the Engineer.

5101 EQUIPMENT: provide necessary facilities and equipment for specified tests in the fabrication shop and on site. Calibrate load measuring equipment at regular intervals agreed with the Engineer.

5201 RESULTS: submit three copies of test and examination results to the Engineer immediately they are available.

5301 WELDS: when required submit specimens of welded joints and weld metal to an approved testing authority for testing to ASTM or as specified by the Engineer.

5311 FILLET WELDS: when required make the following tests on fillet welds in the presence of the Engineer:

penetrant test to ASTM E165; and/or

magnetic particle test to ASTM E709 performed on root pass and on finished weld of fillet welds at random. Cracks or Zones of incomplete fusion or penetration are not acceptable.

5321 BUTT WELDS: when required make the following tests on butt welds in the presence of the Engineer:

radiographic examination to ASTM E94 as appropriate, minimum quality level "2-2T"; and/or

ultrasonic examination to ASTM E94 for 100 percent of full penetration and partial welds.

5551 NON-SHRINK GROUT: prepare 50 mm cubes and test for compressive strength in accordance with ASTM C109/C109M.

# G11 BRICK AND BLOCK MASONRY

## GENERAL

### G11:A SCOPE

A105 SCOPE: this Section is for the specification of concrete, glass and block unit, non-load bearing masonry.

### G11:C SUBMITTALS

C105 DRAWINGS: for each type of block masonry, submit drawings and other information showing such details of the work as the Engineer may reasonably require, including but not necessarily limited to the following:

method of bonding, including type and locations of ties, anchors and reinforcement

built in items

movement joints

joints and connections to adjacent structures, including soffits

openings through fire walls

cavity insulation

damp proof courses.

C120 SAMPLES: submit sample units of each type of block masonry and obtain approval before placing orders with suppliers:

for masonry exposed to view, submit representative samples sufficiently large to show likely variations in colour, texture and finish in the completed work.

C125 CONTROL SAMPLES: prepare sample wall panels approximately 1.2 x 1.2 m of each type of facework, including specified jointing and pointing. After drying out, obtain approval of appearance before proceeding. Construct wall panels with randomly sampled masonry units in an approved location. When directed by the Engineer, construct additional, adjacent sample wall panels from individual batches of corresponding masonry units, for comparison with original approved samples.

## G11:D PERFORMANCE REQUIREMENTS

D105 TESTING CONCRETE BLOCKS: ten block units from each batch are to be selected by the Engineer for compressive strength testing. Test results are to be as follows:

average of 10 blocks: not less than the value specified in Subsection G11:G

any individual block: not less than 80% of the value specified in Subsection G11:G.

D110 TESTING MORTAR: mortar conformance to the property specifications shall be established by tests in accordance with BS 4551, BS EN 1015-1> 4, 6, 7, 19.

D115 REJECTION: failure of selected units to comply with test result requirements for compressive strength and the Specification will result in rejection of the whole batch from which selected blocks were taken.

## MATERIALS AND PRODUCTS

## G11:G BLOCKS

G105 CONCRETE BLOCKS: unless otherwise specified, are to be to BS EN 771-3 tested to BS EN 772-2, nominal size 400 x 200 mm and to the thicknesses shown on the Drawings. Average minimum compressive strength, measured on NET area of block shall be 10 N/mm2 (10 MPa).

Concrete masonry units shall be manufactured from ordinary Portland cement to BS EN197-1 and natural normal weight aggregates to BS EN 12620. Concrete facing blocks are to have true undamaged surfaces and clean and sharp arises. Web thicknesses shall be as follows:

| | |
|---|---|
| units 100 mm thick and less: | not less than 20 mm |
| units 150 mm thick: | not less than 25 mm |
| units 200 mm thick and over: | not less than 35 mm |
| units in external walls supporting stone cladding: | not be less than 40 mm. |

Maximum water absorption for average of 3 units shall be not more than 208 kg of water per 1 m3 of concrete.

G110 FIRE RATING OF CONCRETE BLOCKS: unless otherwise specified, shall be as follows:

| | |
|---|---|
| 100 mm solid blocks: | 2.0 Hour; with 15 mm plaster on both sides |
| 150 mm solid blocks: | 4.0 Hour; with 15 mm plaster on both sides. |

100 mm hollow blocks: 1.0 Hour; with 15 mm plaster on both sides
150 mm hollow blocks: 2.0 Hour; with 15 mm plaster on both sides.
200 mm hollow blocks: 3.0 Hour; with 15 mm plaster on both sides.

Hollow blocks are usually 55% solid.

G120 STC RATING OF CONCRETE BLOCKS: unless otherwise specified, the rating shall be as follows: Typical STC rating of concrete masonry walls are as follows:

| Thickness | w | | 15 mm plaster | |
|---|---|---|---|---|
| Hollow | kg/m2 (PSF) | bare | one side | both sides |
| 100 mm | 90 (18.5) | 43 | 44 | 45 |
| 150 mm | 135 (27.75) | 45 | 46 | 47 |
| 200 mm | 180 (37) | 47 | 48 | 49 |
| 250 mm | 225 (46.25) | 48 | 49 | 50 |
| 300 mm | 270 (55.5) | 50 | 51 | 52 |

| Thickness | w | | 15 mm plaster | |
|---|---|---|---|---|
| Solid | kg/m2 (PSF) | bare | one side | both sides |
| 100 mm | 200 (41.50) | 47 | 48 | 48 |
| 150 mm | 300 (62.25) | 51 | 52 | 53 |
| 200 mm | 400 (83) | 55 | 56 | 57 |
| 250 mm | 500 (103.75) | 58 | 59 | 60 |
| 300 mm | 600 (124.5) | 62 | 63 | 64 |

G510 GLASS BLOCKS: transparent or translucent proprietary hollow glass blocks, providing good thermal insulation and protection against burglary and fire, to the sizes, pattern and colour shown on the Drawings and to approval. Provide manufacturer's standard corner and end block units at angles and return ends.

Man: Saint Gobain
Man: Pittsburgh Corning

or other equal and approved.

G525 GLASS BLOCKWORK FIXINGS ACCESSORIES: provide all standard fixings accessories as recommended by the glass block manufacturer for particular purpose and installation of glass block panels, including but not necessarily limited to: joint reinforcement, expansion strips, ties, anchors and the like.

## G11:H TIES AND ANCHORS

H105 Materials: Provide ties and anchors specified in subsequent paragraphs that are made from materials that comply with subparagraphs below, unless otherwise indicated.
H110 Corrugated Metal Ties: Metal strips not less than 22 mm wide with corrugations having a wavelength of 7.6 to 12.7 mm and an amplitude of 1.5 to 2.5 mm made from steel sheet, galvanized after fabrication not less than 1.3 mm thick.

H120 Adjustable Anchors for Connecting to Structure: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

Connector Section for Concrete: Dovetail tabs for inserting into dovetail slots in concrete and attached to tie section; formed from 1.3-mm- thick, steel sheet, galvanized after fabrication

Tie Section for Concrete: Corrugated metal ties with dovetail tabs for inserting into dovetail slots in concrete and sized to extend to within 25 mm of masonry face.

H130 Dovetail Slots in Concrete: Furnish dovetail slots with filler strips, of slot size indicated, fabricated from 0.9-mm, galvanized steel sheet.

G11:I KERBS

I105 KERBS, EDGINGS AND CHANNELS: manufacturing tolerances shall be 3mm in any one dimension. End and edge faces shall be perpendicular to the base. Bullnoses and curved faces shall be of constant radius with a smooth change from radius to straight face.

I115 PRECAST CONCRETE KERBS: precast concrete units made from normal-weight aggregate conforming to the general requirements of BS 7263-1 & 3, obtained from an approved manufacturer and to the cross sectional shapes and sizes shown on the Drawings, including radius, transitional and special units as indicated and required:

| | |
|---|---|
| Colour: | natural, to approval |
| Exposed finish: | plain face |
| Mortar joints: | narrow |

G11:Y MORTAR

Y115 MORTAR, unless otherwise specified, is to be to the requirements of Section G21 of the Specification, giving compressive strength at 28 days of 5 MPa (minimum cement sand ratio 1:3-4 by volume). Use plasticiser as per manufacturer's printed recommendations.

Y125 MORTAR, factory premixed mortar to BS EN 998-1-2 and to be to the requirements of Section G21 of the Specification. Giving compressive strength at 28 days of 5 MPa (minimum cement sand ratio 1:3-4 by volume)

## WORKMANSHIP

### G11:1 GENERALLY

1011 STANDARD: construct concrete unit masonry in accordance with the requirements of BS 5628-3 and BS 8000-3.

1101 STORING: stack blocks so that they are stable and clear of the ground. Protect from inclement weather and keep dry.

1251 CONDITIONING OF CONCRETE BLOCKS:

do not use autoclaved concrete blocks when still warm from the manufacturing process

do not use non-autoclaved concrete blocks until at least four weeks after casting

do not wet concrete blocks before laying; use an approved water retaining admixture in the mortar to counteract suction.

1501 CONSTRUCT UNIT MASONRY with all materials fully bonded or tied together to ensure compliance with design requirements for stability, strength, fire resistance, thermal and sound insulation as relevant.

1551 CONNECTION BETWEEN WALLS AND PARTITIONS: walls and partitions should generally be bonded, tied or dowelled to one another at angles and junctions. Where it is necessary for a partition to be connected to an adjacent wall or column, this should be done by toothing or block bonding unless otherwise specified

1601 TIE block walling to concrete structural elements with metal ties approved for the purpose.

1701 WET WEATHER: protect newly erected masonry during interruption through rain and at completion of each day's work by covering.

1751 FIRE WALLS: joints between fire-walls and adjacent structures and soffit of slabs are to be tightly finished and well packed to prevent the passage of smoke. All openings in fire-walls are to be provided with sleeves that will prevent the passage of flames and smoke in case of fire.

G11:2 LAYING

2251 UNIFORMITY: carry up work including both leaves of cavity work, with no portion more than 1.2 m above another at any time, racking back between levels. Do not carry up work higher than 1.5 m in one day.

2402 LAY GLASS BLOCKS on full bed of white cement mortar with joints filled to consistent thickness of not more than 12 mm; build-in joint reinforcement, expansion strips, ties, anchors and the like in accordance with the manufacturer's instructions and approved shop drawings. Clean glass block masonry surfaces as soon as practicable after completion using generous amounts of clean water and dry, soft cloths to remove dried mortar and aggregate particles.

2451 LAY HOLLOW BLOCKS with cavity downwards. Do not fill cavities in hollow blocks. Use cut or special shape blocks to make up courses and piece-in.

2501 BUILT-IN WORK: build-in items specified under this and other Sections of the Specification as construction progresses. Fill in solidly with masonry around built-in items.

2551 BUILT-IN FRAMES: fill space between hollow metal frames and masonry, solidly with mortar, unless otherwise indicated.

2601 ACCURACY: keep courses level, true to line and evenly spaced using gauge rods. Accurately plumb all faces, angles and features. Set out carefully to ensure satisfactory junctions and joints with adjoining or built-in elements and components. Unless otherwise specified, build blockwork within the following permissible deviations:

| Dimension | Permissible Deviation (mm) |
|---|---|
| Position in plan of any point or specified fair face in relation to the nearest building grid line at the same level: | +/-10 |
| Length (unless otherwise defined by adjacent construction): | |
| up to 5 m | +/-15 |
| 5 m to 10 m | +/-20 |
| 10 m to 20 m | +/-25 |
| over 20 m | +/-30 |
| Height: | |
| up to 3 m | +/-15 |
| 3 m to 6 m | +/-20 |
| over 6 m | +/-25 |

| | |
|---|---|
| Level of bed joints: | |
| up to 5 m long | +/-10 |
| 5 m to 10 m long | +/-15 |
| over 10 m long | +/-25 |
| Straightness in any 5 m length: | +/-10 |
| Vertically: | |
| in any 3 m height | +/-10 |
| in overall height of building exceeding 6 m | +/-20 |
| Thickness: | |
| Overall thickness of walls or width of piers, (subject to the following): | +/-15 |
| difference in thickness of a wall or width of a pier at any two points 3 m apart | +/-10 |

2651 LIFT SHAFTS: use templates for forming lift shafts accurately at each floor level.

2802 SOFFITS: build non-loadbearing partitions full height of storey to underside of solid floor or roof structure above. Keep a free space of 20 mm approximately between the top course of non-loadbearing partitions and the structure above. Fill this space with impregnated fiberboard. Anchor the top course of non-loadbearing partitions to the structure above with a resilient anchor permitting vertical deflection while preventing lateral movement.

2805 SOFFITS: at fire-rated partitions, install firestopping in joint between top of partition and underside of structure above to comply with Section "Firestopping".

G11:3 ANCHORING MASONRY TO STRUCTURAL MEMBERS

3101 Anchor masonry to structural members where masonry abuts or faces structural members to comply with the following:

Anchor masonry to structural members with anchors embedded in masonry joints and attached to structure.

Space anchors as indicated, but not more than 610 mm o.c. vertically and 915 mm o.c. horizontally.

G11:4 BONDING AND JOINTING

4051 BLOCKWORK BOND, unless otherwise specified, is to be stretching half lap as defined in BS 5628-3, Appendix B.
4101 LINTEL BEARINGS: carefully predetermine setting out so that full block or brick units occur beneath ends of lintels.

4201 UNEXPOSED JOINTS: as the work proceeds, strike off joints that will not be exposed to view in the finished work.

4251 JOINTS IN MASONRY TO BE PLASTERED: as the work proceeds, strike off and leave rough.

G11:6 CAVITY WORK

6051 CAVITY WALLS: keep cavities clean as follows:

exclude mortar or debris by efficient means (e.g. laths, drawholes, thick rope)

ensure there are no ledges or projections which could permit mortar accumulation

prevent any accidental mortar droppings from adhering to cavity trays or wall ties

leave temporary openings at the bottom and in other areas where mortar could accumulate and carefully clean out as necessary, avoiding damage to damp proof courses.

6101 COMPLETE CAVITY FILL INSULATION: fix insulation, as specified in Section J21 “Thermal Insulation”,as follows:

do not use any units that are warped

ensure that units are the correct thickness for the cavity width

build the outer leaf first to at least the height of the first row of insulation units, with ties projecting

unless otherwise specified, commence cavity insulation below damp course level to overlap any ground slab insulation by at least 150 mm

do not push insulation units into cavities under any circumstances

completely clean the wall face of mortar or projections and fix insulation tightly against it with ties or other fixings as specified. Use purpose-made fixings strictly in accordance with the manufacturers printed instructions

space wall ties so that each insulation unit is supported by at least two ties

fix the units a row at a time, the bottom edge resting on the ties, the top edges pushed below the ties above

carefully and accurately slit and fit units over any additional ties around openings, etc.

carefully cut and tightly fit insulation around openings, air bricks, services and other interruptions to the cavity

carefully cut units at wall angles

tightly butt units with staggered vertical joints, ensure there are no gaps in the insulation

keep ties and cavity clean

protect insulation from mortar droppings, particularly at top edges

protect the top of any insulation not extending to the top of the wall with a cavity tray

fix insulation units with their sides vertical.

6151 BOTTOM OF CAVITY: form the bottom of the cavity at least 150 mm below the lowest damp proof course at any point.

6161 COURSING: raise the skins of cavity walls together and approximately equally so that the difference in height does not exceed:

the vertical spacing of consecutive rows of vertical twist pattern ties

1.5 m for all other ties. If one skin is constructed from units of a different height to the other skin, arrange the coursing of the unfaced skin so that appropriate horizontal courses regularly coincide during the height of the walls.

6171 WEEP HOLES: leave vertical joints at 800 mm centres completely open in the masonry course immediately above base of cavity and where bridged at external openings, damp proof courses and the like.

6201 WALL TIES: bed ties not less than 50 mm into each leaf sloping towards the exterior, staggered in alternate courses and spaced at 800 mm centres horizontally and 400 mm centres vertically.

6202 WALL TIES: provide additional ties at sides of openings at every block course.

6251 JAMBS: build solid jambs to openings in cavity walls.

G11:7 DAMP-PROOF COURSES (DPCs)

7051 DAMP-PROOF COURSES: work to flexible dpcs shall be as follows:

in cold weather warm rolls prior to unrolling to avoid cracking

lay an even bed of mortar for dpc and complete the bed to normal thickness and finish smooth

ensure mortar is free from any aggregate that could puncture the dpc

in cavity walls provide a separate dpc for each skin and ensure that the edges do not project into the cavity to create a potential mortar trap. Support cavity trays wherever possible by use of slates or other approved means

at base of cavity walls slope dpcs towards outer skin and weepholes

use un-jointed lengths as much as possible: lap at least 100 mm at passings; lap full width at angles

over openings and under sills in cavity walls, and in all other vulnerable locations, use un-jointed lengths or seal the lap

form watertight joints with any adjacent damp proof membranes

extend dpcs 150 mm beyond lintels

at jambs of openings in cavity walls provide dpc in close contact with frames properly fixed to prevent sagging with a full lap to dpc at head

at sills provide dpc turned up at back and ends with front edge projecting 5 mm

ensure that dpcs are a minimum of 150 mm above ground level, with particular reference to stepped work

leave edges of dpcs projecting 5 mm from face of external walls. do not point in mortar.

# G21 MAKING MORTAR

## GENERAL

### G21:A SCOPE

A105 SCOPE: this Section is for the specification of making mortar in connection with masonry work and tiling.

### G21:C PERFORMANCE REQUIREMENTS

C110 TESTING MORTAR: mortar conformance to the property specifications shall be established by tests in accordance with BS 4551 and BS EN 1015-1> 4, 6, 7, 19 .

## MATERIALS AND PRODUCTS

### G21:Y SAND, CEMENT, ADMIXTURES AND WATER

Y105 SAND FOR MORTAR for walling and stone slab cladding is to be to BS EN 13139. Sand for facework mortar is to be from one source, different loads are to be mixed if necessary to ensure consistency of colour and texture. When a range is specified (e.g. 1:1:5-6) use lower proportion of sand for Grade G sands and higher proportion for Grade S.

Y115 SAND FOR BEDS for tile and slab finishings is to be to BS 13139.

Y205 FACTORY PREPARED MIX: to BS EN 998 -1-2, manufacturer's standard factory-packaged blend of ordinary Portland cement, aggregate, water retaining and other suitable admixtures. Properties shall be as follows:

| | | |
|---|---|---|
| Wet mix life | : | <1.5 hours |
| Initial adhesion at 28 days | : | > 0.3 N/mm2 |
| Bending (flexural) strength | : | not less than 1 N/mm2 |
| Compressive strength | : | 5 ±1 N/ mm2 |
| Minimum cement sand mix | : | 1:3-4 |
| Test | : | BS 4551 |

Y310 CEMENT, unless otherwise specified, is to be ordinary Portland cement to BS EN 197-1 .

Y330 WHITE CEMENT: to BS EN 197-1.

Y405 ADMIXTURES: do not use admixtures, other than plasticisers, without prior approval. Do not use calcium chloride or any admixtures containing calcium chloride.

Y415 PLASTICISERS: to BS EN 934-3.

Y425 LIME: do not use lime.

Y430 PIGMENTS: to BS EN 12878.

Y610 WATER: to be clean, free from silt, organic matter, alkali, salts and other deleterious impurities. Obtain approval of source of supply. Test to BS EN 1008.

## WORKMANSHIP

### G21:1 MIX PROPORTIONS

1051 MORTARS GENERALLY: mix constituents to proportions specified in the relevant Sections of the Specification.

1201 SAND: proportions of mixes given are for dry sand. Allow for bulking if sand is damp.

1202 SAND: where a range is given (eg. 5-6), use higher value for well-graded sand, lower value for coarse or uniformly fine sand.

1251 GAUGE BOXES: measure mortar constituents by volume using clean gauge boxes made to sizes to suit volumes required. Overfill gauge boxes and strike off excess material with straight edge.

1301 PLASTICISER: add as recommended by manufacturer and approved.

1351 DRY ADMIXTURES: dissolve in mixing water for each batch of mortar.

G21:2 MIXING GENERALLY

2051 MIX MORTAR by mechanical mixer or by hand on a clean level banker board. Mix thoroughly so that individual constituents are incorporated evenly. Do not overmix mortars containing plasticisers.

2101 KEEP MIXER CLEAN at all times and discharge mortar on to a clean level banker board.

2151 MAKING MORTAR:

use mortar within thirty minutes of discharge from mixer at normal temperatures. In no case must mortar be used after initial set has taken place. Mortar may be re-tempered to restore workability, but only within this time limit

reconstitution of mortar will not be permitted

use retarded mortar within the time and site temperatures recommended by the manufacturer

mix ingredients thoroughly to a consistence suitable for the work and free from lumps. Mortars containing air entraining admixtures must be mixed by machine, but do not overmix.

2351 CEMENT-SAND-PLASTICISER MORTAR: mix to plasticiser manufacturer's recommendations.

2401 PREMIXED MORTAR: use as per manufacturer’s printed instructions.

G21:3 MIX CONSISTENCIES

3051 MORTAR GENERALLY: mix constituents with minimum amount of water to provide consistence required.

3102 SEMI-DRY MIX MORTAR: mix constituents and add sufficient water to form crumbly consistency which retains its shape when squeezed by hand.

3151 SLURRY: mix constituents and add water to form slurry of creamy consistence.

3201 GROUT: mix constituents and add water to form liquid grout.

# G31 ACCESSORIES AND SUNDRY ITEMS FOR MASONRY

## GENERAL

### G31:A SCOPE

A105 SCOPE: this Section is for the specification of accessories and sundry items in connection with masonry work.

## MATERIALS AND PRODUCTS

### G31:X ACCESSORIES

X105 JOINT REINFORCEMENT: expanded steel mesh to BS 405, of suitable mesh size, galvanised to BS EN ISO 1461 after cutting to width.

X155 TIES FOR BONDING WALLS TO CONCRETE: corrugated metal ties, L-shaped, 40 mm wide x 3 mm thick, 150 x 40 mm long legs. Ties are to be hot-dip galvanised after fabrication.

X255 TIES FOR BONDING LEAVES OF CAVITY WALLS: to BS EN 841-1, galvanised steel, butterfly type 1, fitted with plastics insulation retaining clips recommended by manufacturer for this type of tie.

X305 Adjustable Anchors for Connecting to Structure: Provide anchors that allow vertical or horizontal adjustment but resist tension and compression forces perpendicular to plane of wall.

> Connector Section for Concrete: Dovetail tabs for inserting into dovetail slots in concrete and attached to tie section; formed from 1.3-mm- thick, steel sheet, galvanized after fabrication

X515 EXPANSION BOLTS: for use in hollow unit masonry shall be galvanized steel, appropriate type and size as recommended and certified for particular purpose, function, location and background by the manufacturer, and to approval.

Man: Hilti [http://www.hilti.com/]
Ref: HHD
Man: Artex-Rawlplug [www.artexltd.com]

Man: Artur Fischer

or other equal and approved.

X535 CHEMICAL ANCHORS: for hollow unit masonry use chemical anchors with mesh sleeve.

Man: Hilti [http://www.hilti.com/]
Ref: HY 20

Man: Artex-Rawlplug [www.artexltd.com]
Man: Artur Fischer

or other equal and approved.

X605 MOVEMENT JOINT FILLER: bitumen impregnated fibreboard to ASTM D1751, or as manufactured by:

Man: Grace Construction Products [http://www.graceconstruction.com/]

or other equal and approved.

X655 MULTI-PART NONSAG POLYURETHANE SEALANT: chemically curing, elastomeric sealant of base polymer indicated and which complies with ASTM C 920 requirements, including those referenced Type M, Grade NS, Class 25, or as manufactured by:

Man: Tremco Inc. Tremco Illbruck Ltd [www.tremco-illbruck.com]

Man: Sika [http://www.sika.com/]

or other equal and approved.

## WORKMANSHIP

### G31:2 ANCILLARY WORK

2051 JOINT REINFORCEMENT: lay on an even bed of mortar in a continuous strip with 150 mm laps at joints and full laps at angles. Keep reinforcement back 25 mm from face of external work, 12 mm back from face of internal work and finish mortar joint to normal thickness.

2102 TIES FOR BONDING WALLS TO CONCRETE: fix metal anchors with explosive fasteners or wall plugs.

2111 FIXING TIES IN MASONRY CAVITY WALLS:

bed not less than 50 mm into bed joint of each leaf

slope downwards towards outer leaf with drip centred in the cavity and pointing downwards. Do not bend ties to suit coursing

provide ties at the rate of not less than 1 metal tie for every 0.37 m2 of wall area spaced at maximum 610 mm overall centres horizontally and vertically. Stagger ties in alternate courses

provide additional ties within 300 mm of openings and space not more than 915 mm apart around perimeter of openings

provide additional ties beneath the lowest row of insulation.

2112 TIES: where walls are built as facing to concrete, the ties are to be staggered vertically and horizontally at a rate of 5/m2.

2301 FILLING MOVEMENT JOINTS: build in movement joint filler as work proceeds ensuring no projections into cavities. In joints to be pointed with sealant, position filler accurately at recommended distance from face of wall. Leave joints open for as long as possible before sealing.

2401 BUILDING IN FRAMES: adequately support and protect frames permitted to be built-in, to prevent distortion and damage.

2451 TEMPLATES: where frames are not to be built in, form openings using rigid templates accurately fabricated to required size.

# J14 LIQUID APPLIED WATERPROOF COATINGS

## GENERAL

### J14:A SCOPE

A105 SCOPE: this Section is for the specification of liquid-applied waterproofing systems, other than to substructures, together with associated work and accessories, including:

waterproofing under wet area floor finishes
water repellents to concrete surfaces

### J14:D SUBMITTALS

D110 PRODUCT DATA: submit product data for each type of waterproofing specified, including technical and test data substantiating that materials comply with specified requirements. Include manufacturer's printed instructions for evaluating, preparing, and treating the substrate, and recommendations as to primer, method of application, number of coats, coverage and protection.

D115 DRAWINGS: submit drawings and other information showing such details of the work as the Engineer may reasonably require, including but not necessarily limited to:

locations and extent of each type of waterproofing

show typical details at terminations and penetrations through waterproofing and at expansion and construction joints, upstands, corners, angles and junctions.

D120 Installer Certificates: Signed by product manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install his products.

D125 Installer Experience: List of five (5) projects (minimum) of a similar nature carried out successfully by the installer with the same product endorsed by the manufacturer's representative.

### J14:E QUALITY ASSURANCE

E120 Installer Qualifications: A qualified firm specializing in performing the work of this Section with minimum three years documented experience and that is approved,

authorized, or licensed by the product manufacturer to install his product and that is eligible to receive manufacturer's warranty. Include project names and addresses, names and addresses of architects/ engineers and owners, and other information specified

E205 MATERIALS GENERALLY: provide waterproofing materials recommended by manufacturer to be fully compatible with and able to develop bond to substrate under conditions of service and application required, as demonstrated by waterproofing manufacturer based on testing and field experience.

E225 DELIVER materials to the site in original containers with seals unbroken, labelled with manufacturer's name, product brand name and type, date of manufacture, shelf life, and directions for storing and mixing with other components.

E230 STORE materials in their original undamaged containers in a clean, dry, protected location and within the temperature range required by waterproofing manufacturer. Protect stored materials from direct sunlight.

remove and replace material that cannot be applied within its stated shelf life.

E235 COVERAGE RATE: for liquid applied coatings, calculate the quantity of material needed for the work in accordance with manufacturer’s printed instructions. Submit calculations for Engineer’s approval. Divide the areas to be coated and allocate the appropriate quantity of coating material for each area.

E250 WATERPROOFING WARRANTY: Provide complete system warranty in which Manufacturer, Contractor and Installer are jointly and severally responsible and agree to repair or replace without limitations, all or any part of the membrane waterproofing system which fails or becomes defective in materials or workmanship within specified warranty period. Failure includes, but is not limited to: water penetration, deterioration in membranes and coatings; other than due to normal ageing and weathering; and any defects in adhesion, sealants, flashings, fixings, coverings and other components of the work.

Warranty Period: 20 years from date of Substantial Completion.

## MATERIALS AND PRODUCTS

### J14:R RIGID SHEETS

R101 PROTECTION COURSE: board, one piece cellular extrusion of polypropylene copolymer 4 mm thick.

Man: Cartonal
Ref: Protection boards

or other equal and approved.

J14:V LIQUID COATINGS

V110 SINGLE-COMPONENT MODIFIED POLYURETHANE: high performance, bitumen-free weatherproof and fire resistant, polyurethane-based, elastomeric membrane system. Apply in multi- coats to the thickness recommended by manufacturer.

Man: Tremco Sealant/Weatherproofing Division [http://www.tremcosealants.com/]
Ref: Trempoof 201. one-part moisture curing elastomer
Ref: Trempoof 222. two-part chemically curing elastomer

or other equal and approved.

V315 ELASTICIZED, CEMENTITIOUS, SURFACE WATERPROOFING: two-component, efflorescence-free, with crack bridging and hydrophobic properties; resistant to water and moisture but vapor permeable for all standard applications (vertical, overhead, and horizontal surfaces not exposed to vehicular traffic); with properties meeting or exceeding the following criteria:

| Property | Value | Test |
|---|---|---|
| compressive strength | 40 MPa at 28 days | ASTM C 109M. |
| flexural strength | 10 MPa at 28 days | ASTM C 348. |
| bond strength | 2.5 MPa at 28 days | ASTM C 321. |

Man: Vandex Vandex international Ltd (www.vandex.com)
Ref: Vandex BB 75 E

Man: Sika [http://www.sika.com/]
Ref: Sika topseal 107

or other equal and approved.

V415 BITUMINOUS EMULSION: Water-borne, SBR modified rubberised bitumen coating for cold application.

Man: Bitumat [www.bitumat.com/]
Ref: Aquashield LX

Man: Sika [http://www.sika.com/]

or other equal and approved.

V425 SILICONE-BASED WATER REPELLENT: water borne clear impregnating liquid based on silane polymers. The coating shall be suitable for internal / external applications and for food preparation areas. It shall be appropriate for substrate and shall change neither the appearance and texture nor the vapour permeability of the underlying surface.

Man: Tremco Incorporated [www.**tremco**roofing.com/]
Ref: Vulcem 2211

Man: Weber & Broutin

or other equal and approved.

J14:X ANCILLARY MATERIALS AND ACCESSORIES

Y205 PRIMERS, ADHESIVES AND SEALANTS: types recommended for particular application and purpose by waterproofing product manufacturer.

X210 ACCESSORIES: jointing strips, reinforcing tape, flashings, protection course, etc., are to be types recommended for particular application and purpose by waterproofing product manufacturer.

WORKMANSHIP

J14:1 GENERALLY

1101 CO-ORDINATION: ensure waterproofing manufacturer's written instructions and recommendations and standard details are provided as necessary for co-ordination with related building elements and services.

1201 COMMENCE waterproofing work only after pipe sleeves, vents, curbs, inserts, drains, and other projections through the substrate to be waterproofed have been completed and proceed only after any substrate defects, including honeycombs, voids, and cracks, have been repaired.

1251 AMBIENT CONDITIONS: install waterproofing only within the range of ambient and substrate temperatures and conditions recommended by waterproofing manufacturer.

Do not apply waterproofing to damp or wet substrates, or when relative humidity exceeds 85 percent.

maintain adequate ventilation during preparation, application and curing of waterproofing materials.

1301 PROTECTIVE CLOTHING is to be worn by operatives using spraying equipment and as recommended by the product manufacturer.

## J14:2 PREPARATION OF SUBSTRATES

2101 CLEAN AND PREPARE substrate according to manufacturer's written instructions and recommendations to provide a clean, dust-free, and dry substrate for waterproofing application.

2151 CLEAN to effectively remove dust, dirt, efflorescence, grease and oil from surfaces generally and curing compounds, form release agents and other contaminants from concrete, that may prevent adhesion or penetration of waterproofing. Remove surface projections and fill honeycomb, aggregate pockets, and other voids.

2201 MASK OFF and protect adjoining surfaces not receiving waterproofing and joint spaces intended for sealants and gaskets in order to prevent spillage or overspray damaging or adversely affecting adjacent components and construction.

2251 SEAL OFF drains, outlets and other penetrations to protect against spillage and prevent migration of waterproofing fluids.

## J14:3 LIQUID-APPLIED WATERPROOFING

3101 INSTALL liquid-applied waterproofing systems including ancillaries and accessories, in accordance with manufacturer's written instructions and recommendations, unless more stringent requirements are indicated or where project conditions require extra precautions to ensure satisfactory performance of work.

3201 PREPARE AND TREAT:

vertical and horizontal surfaces at terminations and penetrations through waterproofing and at expansion joints, drains and sleeves; sealing, filling, applying bond-breakers, installing flashings and the like, according to recommendations

corners, angles, junctions, construction joints and cracks; installing fillets, and reinforcing strips, applying additional waterproofing coats and the like, according to recommendations.

3251 PRIME prepared substrate when recommended, at required rate and allow to dry.

3301 MIX waterproofing materials and components using recommended methods, tools and containers.

3321 APPLY waterproofing according to recommendations, by brush, spray, roller, trowel, or other application method suitable to substrate slope

apply evenly to fill voids and pores of substrate

keep tools clean and free from build-up.

3351 APPLY the number of coats recommended by the manufacturer for the particular substrate, purpose and required function, and at the rates recommended for each coat.

at wall terminations and vertical surfaces, apply waterproofing to heights indicated or otherwise recommended.

J14:4 TESTING

4101 FLOOD TEST each of the following deck areas for leaks after waterproofing and before overlying construction is placed. Plug or dam drains, construct temporary barriers and fill with water to the depth indicated, unless otherwise agreed with the Engineer. Flood each area for 48 hours:

waterproofing under wet area floor finishes, to a depth of 50 mm.

4201 INSPECT and observe for leaks. Submit test reports to the Engineer.

4251 TEST water repellents in accordance with ASTM E 514

4301 CORRECT deficiencies in or remove waterproofing that does not comply with requirements, repair substrates, reapply waterproofing and repair flashings.

repeat flood tests and make further repairs until the waterproofing installation is watertight.

## J14:5 CURING, PROTECTING, AND CLEANING

5101 CURE waterproofing according to manufacturer's recommendations, taking care to prevent contamination and damage during application stages and curing.

5201 PROTECT waterproofing from damage and wear during remainder of construction period when not concealed or protected by permanent construction immediately after installation:

do not permit traffic on unprotected waterproofing.

5301 PROTECTION COURSE: where indicated or recommended by waterproofing manufacturer, install protection course over completed and cured waterproofing treatments. Provide type indicated or otherwise recommended and comply with recommendations for method of support or attachment.

5401 CLEAN and remove any spillage, overspray or soiling from adjacent surfaces not intended to receive waterproofing using cleaning agents and procedures recommended by manufacturer of affected surfaces.

# J21 THERMAL INSULATION

## GENERAL

### J21:A SCOPE

A105 SCOPE: this Section is for the specification of board thermal insulation, including roof insulation for use with wall insulation and inverted roof systems; together with associated works and accessories

## MATERIALS AND PRODUCTS

### J21:R1 ROOF INSULATION

R110 EXTRUDED POLYSTYRENE ROOF INSULATION: extruded board 50 mm thick to BS EN 13164 (ASTM C578 type V1), having the following minimum properties:

| Property | Standard | Value |
|---|---|---|
| Density | | 38 kg/m3 |
| Thermal conductivity (K) | | 0.029 W/m°K |
| Compressive strength at 5% compression | BS EN 826 | 300 kPa [0.3 N/mm2] |
| Water absorption (by immersion) | BS EN 12087 | <0.5 % by volume |
| Burning characteristics | BS EN 13164 | Class E, Max 150 mm |

Man: Dow Chemical Company [http://www.dow.com/styrofoam/index.htm]
Ref: Roofmate SL-X

or other equal and approved

### J21:R2 WALL INSULATION

R220 EXTRUDED POLYSTYRENE WALL INSULATION: extruded board to BS EN 13164, 50 mm thick, having the following minimum properties:

| Property | Standard | Value |
|---|---|---|
| Density | BS EN 1602 | 38 kg/m3 |
| Thermal conductivity (K): | BS EN 12667 | 0.029 W/m°C |
| Flexural strength | | 413 kPa |
| Compressive strength at 5% compression | BS EN 826 | 300 kPa [0.3 N/mm2] |
| Water absorption (by immersion) | BS EN 12087 | <0.5 % by volume |
| Burning characteristics | BS EN 13164 | Cass E, Max 150 mm |

Man: Dow Chemical Company [http://www.dow.com/styrofoam/index.htm]
Ref: Wallmate

or other equal and approved

J21:Y PRIMERS AND COMPOUNDS

Y105 ADHESIVES AND COATINGS: types recommended for particular purpose by manufacturer of thermal insulation.

Y250 HOT BONDING BITUMEN: oxidized bitumen for hot application, to ASTM D 312, Type IV: softening point 99 - 107 deg.°C (ASTM D 36), and penetration at 25 deg.C: 12-25 (ASTM D 5).

## WORKMANSHIP

### J21:1 GENERALLY

1101 HANDLE, STORE AND INSTALL insulation in accordance with manufacturer's instructions applicable to the particular use:

clean substrates of substances harmful to insulation and remove any projections that interfere with placement or attachment

use only insulation that is undamaged, dry and unsoiled

extend insulation in thickness indicated to cover or envelop entire area to be insulated. Cut and fit tightly around obstructions and fill voids with insulation

unless multiple layers are otherwise shown or required to make up total thickness, install a single layer of insulation of thickness indicated.

1251 CAVITY WALL INSULATION: boards used for cavity wall insulation are to be selectively sized to suit wall tie spacing.

### J21:3 INVERTED ROOF INSULATION

3101 INSULATION BOARD: lay boards loose over waterproofing membrane. Unless otherwise specified, cover insulation boards with ballast, roof tiles or screed topping, as indicated.

3201 INSULATION BOARD: do not lay until roof is clear of other trades and sub-trades:

clean off all dirt and debris from base

lay boards loose, tightly butted with staggered end joints, cut cleanly to fit closely around projections, upstands, rainwater outlets and the like

on completion of laying ensure that boards are in good condition, with no springing, flexing or rocking; protect, and install roof surface covering as soon as practicable.

3301PROTECT insulation boards which are liable to be damaged from construction traffic with suitable measures approved by the Engineer.

## J21:4 WALL INSULATION

4101 POLYSTYRENE BOARD INSULATION: fix securely with tightly butted joints using metal fixings, ensuring that:

edges are not damaged

top edges are covered with a temporary batten to ensure that they remain completely free of mortar droppings, grout and other debris

all parts of inner leaf cavity face are covered

place and secure each course of insulation before building up inner leaf above level of previous course of insulation.

# J31 MOVEMENT JOINTS

## GENERAL

### J31:A SCOPE

A105 SCOPE: this Section is for the specification of movement joints and joint covers in architectural finishes, and is to be read in conjunction with Sections E41, G31, J11, J12 and J13 of the Specification.

### J31:C DEFINITIONS

C105 TRAFFICABLE SEALANT: to qualify for traffic use under ASTM C 920 requirements, elastomeric sealants must demonstrate a shore A hardness of not less than 25 nor more than 50

C110 LOW MODULUS: tensile strength of 310 kPa or less.

C120 HIGH MODULUS: tensile strength of more 517 kPa. Joint movement is limited to ±25% or less

### J31:D PERFORMANCE REQUIREMENTS

D105 Provide elastomeric joint sealants that establish and maintain watertight and airtight continuous joint seals without staining or deteriorating joint substrates.

### J31:E SUBMITTALS

E105 Product Data: For each joint-sealant product indicated.

E110 SHOP DRAWING: submit manufacturer's installation instructions and shop drawings with expansion joint cross-section(s) indicating pertinent dimensions, general construction, component connections, and anchorage methods.

E115 Samples for Initial Selection: Manufacturer's colour charts consisting of strips of cured sealants showing the full range of colours available for each product exposed to view.

E120 Product Certificates: Signed by manufacturers of joint sealants certifying that products furnished comply with requirements and are suitable for the use indicated.

E125 Installer Certificates: Signed by product manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install his products.

E130 Installer Experience: List of five projects (minimum) of a similar nature carried out successfully by the installer with the same product endorsed by the manufacturer's representative.

E135 Compatibility and Adhesion Test Reports: From sealant manufacturer indicating that the materials forming joint substrates and joint-sealant backings have been tested for compatibility and adhesion with joint sealants.

J31:F QUALITY ASSURANCE

F105 Installer Qualifications: An experienced installer with minimum three years documented experience and who has specialized in installing joint sealants similar in material, design, and extent to those indicated for this Project and whose work has resulted in joint-sealant installations with a record of successful in-service performance. with minimum three years documented experience

F110 Source Limitations: Obtain each type of joint sealant through one source from a single manufacturer.

F120 Mockups: Before installing joint sealants, apply elastomeric sealants to verify selections made under sample Submittals and to demonstrate aesthetic effects and qualities of materials and execution.

J31:G WARRANTY

G105 INSTALLER'S WARRANTY: Written warranty, signed by Installer agreeing to repair or replace elastomeric joint sealants that do not comply with performance and other requirements specified in this Section within Two years from date of Substantial Completion.
G110 MANUFACTURER'S WARRANTY: Written warranty, signed by elastomeric sealant manufacturer agreeing to furnish elastomeric joint sealants to repair or replace those that do not comply with performance and other requirements specified in this Section within 10 years from date of Substantial Completion.

G120 EXCLUSIONS: warranties specified in this Article exclude deterioration or failure of elastomeric joint sealants from the following:

Movement of the structure resulting in stresses on the sealant exceeding sealant manufacturer's written specifications for sealant elongation and compression caused by structural settlement or errors attributable to design or construction.

Disintegration of joint substrates from natural causes exceeding design specifications.

Mechanical damage caused by individuals, tools, or other outside agents.

Changes in sealant appearance caused by accumulation of dirt or other atmospheric contaminants.

## MATERIALS AND PRODUCTS

### J31:H SECTIONS

H205 ALUMINUM EXTRUSIONS: material shall conform to ASTM B221; alloy 6005-T5 or 6063-T6.

H210 BACKING CORD: closed-cell, polyethylene foam in circular cross section cords to be used in movement joints as a back-up material and bond breaker for sealants. It is not to be used in locations subject to direct surface pressure such as floors and water retaining structures.

H215 PREFORMED JOINT SEAL: cellular neoprene circular section cord sleeved with a water proof self-adhesive composition.

Man: Grace Construction Products (Servicised) [www.graceconstruction.com]
Ref: Servicore PA.

or other equal and approved.

H216 PREFORMED JOINT SEAL: flexible, pre-compressed, bituminised, foamed polyurethane sealing strip pre-decorated with aluminium primer for further painting on site.

Man: Compriband Ltd. [www.tremco-illbruck.co.uk ]
Ref: Compriband V

or other equal and approved.

H255 EXPANSION JOINT COVER: extruded aluminium expansion joint cover strip.

Man: Balco Inc. [http://www.balcousa.com/]

Man: Construction Specialities [http://www.c-sgroup.co.uk/]

or other equal and approved.

H260 DESIGNED EXPANSION JOINTS: comprising metal sections and sealants of the types shown on the Drawings. Components are to be as follows:

extruded aluminium sections to BS 1161 and the requirements of section M11 [ASTM B 221M, alloy 6063-T5 for extrusions; ASTM B 209M, alloy 6061-T6, sheet and plate]. Protect aluminum surfaces to be placed in contact with cementitious materials with a protective coating.

extruded preformed seals: Single or multicellular elastomeric profiles as classified under ASTM D 2000, designed with or without continuous, longitudinal, internal baffles. Formed to fit compatible frames, in colour as selected by Engineer.

backing cord, bond-breaker, primers and sealers are to be types recommended for particular purpose by sealant manufacturer.

seismic seals: Typically for exterior application, two single-layered elastomeric profiles, one interior and one exterior, as classified under ASTM D 2000; retained in a set of compatible frames, in colour indicated or, if not indicated, as selected by Architect from manufacturer's standard colours. If approved by Engineer, omit interior profile for interior application.

H265 EXPANSION JOINTS COVER: floor, wall and ceiling joint cover comprising pre-formed strips of neoprene set in stainless steel sections, drilled for and including anchor loops. Cover assembly is to allow movement equal to +/- 50 % of the nominal joint width.

Man: Marble Flooring Specialists Ltd [Web: www.marbleflooring.co.uk]

Man: Construction Specialities [http://www.c-sgroup.co.uk/]

Man: Pawling Corporation [http://www.pawling.com/]
Ref: Joint Master

or other equal and approved.

H275 FIRE BARRIER: insert prefabricated fire barrier assemblies that have been tested in accordance with BS 476-20 and 22, UL 263 procedures for the rating of two hours unless indicated otherwise. These fire barriers shall be inserted in joints in slabs and in fire rated

walls. Material is to carry the label of an independent testing laboratory. Fire barrier assemblies are to include fire barrier and encapsulated insulation.

J31:L FLEXIBLE SHEETS

L210 POLYTHENE TAPE BOND-BREAKER: type recommended for particular purpose by sealant manufacturer.

J31:R RIGID SHEETS

R205 MOVEMENT JOINT FILLER: refer to Sections E41 and G31 of the Specification.

R505 CELLULAR POLYETHYLENE FILLER: rot proof, non-absorbent, U.V. resistant, closed cell polyethylene joint filler.

J31:X ACCESSORIES AND FASTENINGS

X105 RAWLPLUGS: plastic plugs for screw fixings.

Man: Artex Rawlplug Company Ltd [www.artexltd.com]

or other equal and approved.

X150 ALUMINIUM SCREWS: to BS 1473, alloy 2014 A fully heat treated for use with aluminium sheets.

J31:Y PRIMERS AND SEALANTS

Y205 PRODUCTS to be used in conjunction with movement joint sealant are to be types recommended for particular purpose by sealant manufacturer.

Y220 PRIMER: type recommended by sealant manufacturer.
Y310 MULTI-PART NONSAG POLYURETHANE SEALANTS: chemically curing, elastomeric sealant of base polymer indicated which complies with ASTM C 920, properties shall be as follows:

| Manufacturer | Product | Type | Grade | Class | Shore A | Movement Capability | Uses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | T | NT | M | G | A | O |
| Tremco | Vulkem 922 | M | NS | 25 | 20-25 | ±50% | ● | ● | ● | | ● | ● |
| Sika | Sikaflex-2c | M | NS | 25 | 25±5 | ±50% | | ● | ● | ● | ● | ● |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NS | | | | | | | | | | | |
| Tremco | DYmeric | M | NS | 25 | 25±5 | ±50% | ● | ● | ● | | ● | ● |

or other equal and approved.

Y315 MULTI-PART TRAFFICABLE POLYURETHANE SEALANTS: trafficable chemically curing, elastomeric sealant of base polymer indicated which complies with ASTM C 920, properties as follows:

| Manufacturer | Product | Type | Grade | Class | Shore A | Movement Capability | Uses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | T | NT | M | G | A | O |
| Tremco | Vulkem 922 | M | NS | 25 | 20-25 | ±50% | ● | ● | ● | | ● | ● |
| Sika | Sikaflex-2c SL | M | P | 25 | 40±5 | ±25% | ● | ● | ● | ● | ● | ● |
| Tremco | DYmeric | M | NS | 25 | 25±5 | +50% | ● | ● | ● | | ● | ● |
| Tremco | THC-900 | M | P | 25 | 25-30 | ±25% | ● | | ● | | ● | ● |
| Tremco | THC-901 | M | P | 25 | 25-30 | ±25% | ● | | ● | | ● | ● |

or other equal and approved.

Y320 ONE-PART NONSAG SILICONE SEALANT: neutral curing, elastomeric sealant of base polymer indicated which complies with ASTM C 920, properties shall be as follows:

| Manufacturer | Product | Type | Grade | Class | Shore A | Movement Capability | Uses | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | T | NT | M | G | A | O |
| Dow Corning | 790 | S | NS | 25 | 15 | +100 /-50 % | ● | ● | ● | | ● | ● |
| Dow Corning | NS parking structure sealant | S | NS | 25 | 15 | +100 /-50 % | ● | | ● | | ● | ● |
| Tremco | Spectrum 1 | S | NS | 25 | 15 | +100 /-50 % | | ● | ● | | ● | ● |
| Tremco | Spectrum 2 | S | NS | 25 | 35-40 | ±25% | | ● | | ● | ● | |

or other equal and approved.

Y455 COLOUR of sealants applied to exposed joints in architectural finishes is to be approved and selected by the Engineer from manufacturer's standard range.

## WORKMANSHIP

### J31:1 GENERALLY

1101 STRUCTURAL MOVEMENT JOINTS: provide movement joints in architectural finishes where such joints occur in the structural substrate, as shown on the Drawings. Joints to extend to the full depth of the finishing layer, including beddings and backings.

1102 MOVEMENT JOINTS: co-ordinate with requirements of Clause 1101 and provide 10 mm wide, non-structural, peripheral movement joints in floor tiling around the perimeter of all tiled areas:

exceeding 6 m in any direction for ceramic tiles bedded in semi dry mix

exceeding 15 m in any direction for other types of rigid floor tiles or slabs.

Joints to extend to the full depth of the finishing layer, including bedding.

1103 MOVEMENT JOINTS: co-ordinate with requirements of Clause 1101 and provide 10 mm wide, non-structural, intermediate movement joint in floor tiling of all tiled areas:

at 9 m in any direction for ceramic tiles bedded in semi dry mix

at 4.5 m in any direction for ceramic tiles in other bedding

at 15 m in any direction for other types of rigid floor tiles or slabs.

Joints to extend to the full depth of the finishing layer, including bedding.

1104 MOVEMENT JOINTS: provide 10 mm wide, non-structural horizontal and vertical movement joints in natural stone wall cladding as detailed on Drawings. Refer to Section H51 of the Specification.

1105 MOVEMENT JOINTS: submit co-ordinated drawings showing location of design and other movement joints.

1151 SEALING: to be executed only within limits of ambient temperature range recommended by manufacturer.

1201 JOINT DESIGN AND SHAPE: to be as shown on the Drawings.

1251 WATER-TIGHT JOINTS: for joints in wet areas or areas that may become exposed to water, **DO NOT** rely on sealant only, install water-stops, or extend waterproofing membrane across the joint with an expansion loop.

1301 TWIN CURB UPSTAND: extend waterproofing over the upstand and across the expansion joint with a loop formed with a 50 mm diameter rubber pipe. Cover with aluminium flashing secured with stainless steel clips.

J31:2 JOINT PREPARATION

2051 PREPARATION: surfaces to be sealed are to be clean, dry and free from dirt, laitance, dust and deleterious materials. Remove oil and grease with recommended solvent.

2101 JOINT FILLER: expansion joint filler or back-up material be checked to ensure that it is tightly packed and that no voids exist at base of joint.

2151 BACK-UP MATERIAL: use backing cord as support for joint sealant in walls and ceilings and other surfaces not subject to direct surface pressure. Use polythene tape over joint filler as support and bond-breaker for sealants in surface subject to direct surface pressure such as floors.

2201 MASKING TAPE: use masking tape on sides of joint to protect adjacent finishes from smears of sealant and to give sharp and exact seal lines. Remove tape immediately after finishing (tooling) seal and before a skin begins to form.

2251 PRIMER: follow manufacturer's instructions when using primer.

J31:3 APPLICATION

3051 SEALANT APPLICATION: mix two-part sealants using recommended equipment and strictly in accordance with manufacturer's instructions.

3101 SEALANT APPLICATION: sealant is to be applied by gun with nozzle of correct size to fit joint width and with sufficient force to fill groove solidly.

3151 TOOLING SEALANT: tool surface of sealant immediately after application using surface lubricant recommended by sealant manufacturer. Masking tape is to be removed immediately after tooling.

# K31 PLASTERBOARD LININGS, PARTITIONS AND CEILINGS

## GENERAL

### K31:A SCOPE

A105 SCOPE: this Section is for the specification of gypsum plasterboard assemblies for walls and ceilings, including non-load bearing steel framing, furring and support members.

### K31:C SUBMITTALS

C105 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of the work as the Engineer may reasonably require.

C110 SAMPLES: before placing orders submit representative samples of all types of framing and furring members and gypsum plasterboard materials. Ensure that delivered materials match samples.

C115 CONTROL SAMPLES: for each type of plasterboard assembly: lining, partition and ceiling, erect and complete an area of finished work not less than 10 m2 in an approved location and obtain approval of appearance before proceeding.

### K31:D QUALITY ASSURANCE

D105 INSTALLER QUALIFICATIONS: a qualified firm specializing in performing the work of this Section with minimum three years documented experience and that is approved, authorized, or licensed by the product manufacturer to install his product and that is eligible to receive manufacturer's warranty. Include project names and addresses, names and addresses of Engineers and Owners, and other information specified.

D110 SINGLE-SOURCE RESPONSIBILITY FOR STEEL FRAMING: obtain steel framing members for gypsum board assemblies from a single manufacturer, unless otherwise indicated.

D115 SINGLE-SOURCE RESPONSIBILITY FOR PANEL PRODUCTS: obtain each type of gypsum board and other panel products from a single manufacturer.

D120 SINGLE-SOURCE RESPONSIBILITY FOR FINISHING MATERIALS: obtain finishing materials from either the same manufacturer that supplies gypsum board and other panel products or from a manufacturer acceptable to gypsum board manufacturer.

D125 FIRE-TEST-RESPONSE CHARACTERISTICS: where fire-resistance-rated gypsum board assemblies are indicated, provide gypsum board assemblies that are identical to assemblies tested for fire resistance according to ASTM E 119 by an independent testing and inspecting agency acceptable to Engineer.

D130 SOUND TRANSMISSION CHARACTERISTICS: for gypsum board assemblies with STC ratings, provide materials and construction identical to those tested in assembly indicated, according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency acceptable to Engineer.

STC-Rated Assemblies: indicated by design designations from GA-600, "Fire Resistance Design Manual." Ratings shall be as indicated on drawings:

STC rating of 54 or less, as indicated on Drawings.

D135 MOCKUPS: Prior to finishing gypsum board assemblies, construct mockups of at least 10 m2 in surface area to demonstrate aesthetic effects of finishes as well as qualities of materials and execution. Simulate finished lighting conditions for review of in-place unit of Work.

construct mockups for each type of surfaces and finishes

build mockups to comply with the following requirements, using materials indicated for final unit of Work:

locate mockups on-site in the location and of the size indicated or, if not indicated, as directed by Engineer.

notify Engineer one week in advance of the dates and times when mockups will be constructed.

demonstrate the proposed range of aesthetic effects and workmanship.

obtain Engineer's approval of mockups before start of final unit of Work.

retain and maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

approved mockups in an undisturbed condition at the time of Substantial Completion may become part of the completed Work.

K21:E GUARANTEE

E105 GUARANTEE: Provide complete system warranty in which Manufacturer Installer and Contractor are jointly and severally responsible and agree to repair or replace, without limitations, all or any part of the plasterboard linings, partitions and ceilings which fails or becomes defective in materials or workmanship within specified guarantee period. Defects not limited to:

Failures include, but are not limited to, the following:

Structural failures including, but not limited to, excessive deflection.

Failure in fixings.

Failure of system to meet performance requirements.

Warranty Period: [Five] [10] <Insert number> years from date of Substantial Completion.

MATERIALS AND PRODUCTS

K31:H SECTIONS

H210 STUDS AND FURRINGS: made from galvanized mild steel sheet to ASTM C645 or BS EN 10143, designation Z2 G275 N and passivated. Sheet thickness is not to be less than 0.56 mm for studs up to 3600 mm high, channels and furrings and not less than 0.71 mm for studs up to 4200 mm high.

H215 WIRE HANGERS: ASTM A 641/ 641M, Class 1 zinc coating, soft temper, 4.1 mm diameter.

H220 HANGER RODS: mild steel hot-dip galvanized.

H225 FLAT HANGERS: mild steel hot-dip galvanized paint.

K31:R RIGID SHEETS

R210 GYPSUM PLASTERBOARD GENERALLY: wallboards and baseboards to BS EN 520, ASTM C 1396/1396 M. Select type recommended and suitable for particular use,

purpose, exposure and finish; 12.7 mm thick with tapered edges unless otherwise indicated. Gypsum wallboards shall be as follows:

Type: Regular for vertical surfaces, unless otherwise indicated.

Type: Type X where required for fire-resistance-rated assemblies.

Edges: Tapered and featured (rounded or beveled) for prefilling.

Thickness: 15.9 mm where indicated. For fire rated boards, select thickness necessary to achieve specified fire resistance.

Man: United States Gypsum Co. (USG).: http://www.usg.com/

Man: National Gypsum Co.: http://www.nationalgypsum.com/
Ref: Gold Bond Building Products Division.

Man: Knauf

or other equal and approved.

## K31:Y FIXING, JOINTING AND FINISHING MATERIALS AND ACCESSORIES

Y105 GENERALLY: fixing, jointing and finishing materials and accessories, where not otherwise specified, are to be as recommended for particular purpose and application by plasterboard manufacturer.

Y110 SCREWS: zinc or cadmium plated self-drilling and tapping screws with countersunk heads, size 22 mm x 6 gauge.

Y120 JOINTING COMPOUNDS for plasterboard are to be proprietary drying-type factory-packaged vinyl-based factory-mixed products complying with specified requirements for formulation and intended use.

Y125 JOINT TAPES: are to be pressure sensitive or staple attached proprietary reinforcing tapes, compatible with and as recommended for particular purpose and application by jointing compound manufacturer.

Y205 ACOUSTICAL SEALANT: acoustical sealant for exposed and concealed joints shall be manufacturer's standard nonsag, paintable, nonstaining latex sealant complying with ASTM C 834. It shall be effective in reducing airborne sound transmission through

perimeter joints and openings in building construction as demonstrated by testing representative assemblies according to ASTM E 90.

Man: United States Gypsum Co. (USG).: http://www.usg.com/
Ref: Sheetrock Acoustical Sealant

or other equal and approved.

## WORKMANSHIP

### K31:1 GENERALLY

1051 STANDARDS: work in this section shall be carried out in accordance with the following standards and codes of practice:

BS EN ISO140-3: measurement of sound insulation in buildings and of building elements.

BS EN ISO 717- 1 and 2: methods of rating the sound insulation in buildings and building elements.

BS 8000- 8: code of practice for plasterboard partitions and dry linings.

BS 8212: code of practice for dry lining and partitioning using gypsum plasterboard.

1201 QUALITY OF WORK:

handle, store, fix and install materials and products in accordance with manufacturer's recommendations and instructions, ensuring compliance with design and performance requirements

set out accurately, true to line, level and plumb

fix boards only in areas which have been made weathertight

cut boards neatly and accurately without damage to core or tearing of paper facing; keep cut edges to a minimum and position at internal angles wherever possible; mask with bound edges of adjacent boards at external corners

fix boards securely and firmly; finish neatly to give flush, smooth, flat surfaces, free from bowing and abrupt changes of level; do not use damaged boards

operatives are to be properly trained in partitioning and lining work.

1301 ADDITIONAL NOGGINGS: ensure that noggings, bearers etc. required to support fixtures, fittings and services are accurately positioned and securely fixed within partitioning and lining. After fixing boards, mark positions of noggings, bearers etc. for following trades.

K31:2 ERECTING AND FINISHING

2051 GENERALLY: unless otherwise specified, install steel framing in accordance with ASTM C 754 and requirements of ASTM C 840 applicable to framing installations. Install and finish gypsum plasterboard panels in accordance with ASTM C 840.

2101 PARTITIONING:

studs at wall junctions and floor/soffit channels are to be fixed securely at 600 mm centres

position studs at equal centres, maintaining sequence across openings; provide additional studs as necessary to ensure support to all vertical edges of boards

vertical joints between boards on opposite sides of partitions are to be staggered

fix boards to each stud and along all edges with drywall screws at not more than 300 mm centres and not less than 10 mm from edge of board; set screw heads in a depression; do not break paper or gypsum core.

2151 SOUND / FIRE RATED PARTITIONS:

provide 15.9 mm plasterboard, applied at right angles to resilient channels with self-tapping steel screws spaced 200 mm centres. along edges of board and 300 mm centres in the field of the board. Plasterboard joints are to be oriented vertically and staggered on opposite sides of the assembly. Resilient channels are to be spaced at 600 mm centres and fixed to 89 mm 1.0 mm thick metal studs spaced 600 centres

opposite side, provide 13 mm baselayer applied to studs with self-tapping steel screws spaced 300 mm centres and apply 13 mm face sheet with self-tapping steel screws spaced 300 mm centres Provide 50 mm thick mineral or glass fiber insulation within the stud cavity and maintain air gap

provide gypsum board assemblies and materials and construction identical to those of assemblies whose STC ratings were determined according to ASTM E 90 and classified according to ASTM E 413 by a qualified independent testing agency. STC Rating shall not be less than 54

provide gypsum board assemblies with a fire-resistance rating of 30 minutes.

2201 LININGS TO SOLID BACKGROUNDS:

set out furrings vertically, at 600 mm centres and adjacent to angles and openings; bed in 200 mm long dabs of adhesive at 450 mm centres; bed short lengths of furring horizontally to provide continuous support to top and bottom edges of boards; accurately align all furrings to a true, vertical plane, ensuring that cavity width is maintained

working from centre of each board, screw to all furrings at not more than 300 mm centres and not less than 10 mm from edge of board; set screw heads in a depression; do not break paper or gypsum core.

2301 SUSPENDED AND FURRED CEILINGS:

Unless otherwise specified suspend ceiling hangers and support framing from building structure and as follows:

install hangers plumb and free from contact with insulation or other objects within ceiling plenum that are not part of supporting structural or ceiling suspension system

where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with the location of hangers required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices; size supplemental suspension members and hangers to support ceiling loads within performance limits established by referenced standards

secure wire hangers by looping and wire-tying, either directly to structures or to inserts, eyescrews, or other devices and fasteners that are secure and appropriate for substrate, and in a manner that will not cause them to deteriorate or otherwise fail

secure flat, angle, and rod hangers to structure, including intermediate framing members, by attaching to inserts, eyescrews, or other devices and fasteners that are secure and appropriate for structure as well as for type of hanger involved, and in a manner that will not cause them to deteriorate or otherwise fail

do not support ceilings directly from permanent metal forms; furnish cast-in-place hanger inserts that extend through forms

do not attach hangers to steel deck tabs

do not attach hangers to steel roof deck; attach hangers to structural members

do not connect or suspend steel framing from ducts, pipes, or conduit

install suspended steel framing components in sizes and at spacings indicated, but not less than that required by the referenced steel framing installation standard:

| | |
|---|---|
| wire hangers: | 1200 mm centers |
| carrying channels (main runners): | 1200 mm centers |
| furring channels (furring members): | 400 mm centers |

installation tolerances: install steel framing components for suspended ceilings so that cross-furring or grid suspension members are level to within 3 mm in 3.6 m as measured both lengthwise on each member and transversely between parallel members

wire-tie or clip furring members to main runners and to other structural supports as indicated.

Unless otherwise specified, fix, join and finish boards using methods and materials as recommended by the board manufacturer and as follows

where not shown otherwise, provide movement joints as appropriate for the area of ceiling and/or to coincide with movement joints in surrounding structure

cut boards neatly and accurately without damaging surfaces and cores. Do not use damaged boards

screw boards securely and firmly to grid members to give a flat surface free from bowing and lipping. Set heads of screws below surface of boards and fill flush with surface

stagger joints of boards applied in two or more layers. Ensure that edges and ends of each board are fully supported and screwed to grid members.

2401 JOINTS between tapered edges of boards are to be lightly butted. Leave a 3 mm gap where cut or unbound edges occur.

2451 HORIZONTAL JOINTS will not be permitted in partitioning or wall linings except where heights exceeds maximum available length of board. Agree positions of joints where not specified.

2501 TAPED SEAMLESS FINISH:

lightly sand cut edges of boards to remove paper burrs; apply PVAC sealer to exposed cut edges of boards to which tape is to be applied

fill all joints and gaps and cover with continuous lengths of tape, fully bedded; when set, cover with joint finish, feathered out to give a flush, smooth, seamless surface; apply two coats of joint finish at external angles

spot nail and screw depressions with joint filler and when set apply a continuous overall coat of joint finish, feathered off to give a flush, smooth surface

fill minor indents and, after joint, angle and spotting treatments have dried, apply surface finish slurry to give a continuous, consistent texture to surface of boards.

# K41 METAL AND WOOD PARTITIONS

## GENERAL

### K41:A SCOPE

A105 SCOPE: this Section is for the specification of metal partitions and related accessories, other than sliding/folding partitions.

### K41: CSUBMITTALS

C105 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of the work as the Engineer may reasonably require including elevations, plans and full size sections, proposed methods of fixing, proposed methods of forming joints and any proposals for fabricating large components in more than one piece.

C110 SAMPLES: submit samples of materials and obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

C120 MOCKUPS: for each type of metal partitions, complete a sample area, to demonstrate aesthetic effects and set quality standards for materials, fabrication and installation. Construct the sample area being part of the finished work, in approved locations and size not less than 10 m2, including relevant fixings and accessories. Obtain approval of appearance before proceeding with further fixing.

Locations of Mockups: As instructed by Engineer.

Extent of Mockups: Approximately 9 sq. m of surface for each product indicated.

Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

K11: D GUARANTEE

D105 GUARANTEE: Provide complete system warranty in which Manufacturer, Contractor and Installer are jointly and severally responsible and agree to repair or replace without limitations, all or any part of the metal partitions which fails or becomes defective in materials or workmanship within specified warranty period.

Guarantee Period: 15 years from date of Substantial Completion.

MATERIALS AND PRODUCTS

K41:K PARTITIONS

K150 METAL OFFICE PARTITIONS: comprising metal framework, infill panels, openings for glazing, doors and door frames. System is to have provision for running concealed electrical services and is to be supplied complete with manufacturer's standard cover strips, skirtings, glazing beads, ironmongery, accessories and fixings. Components are to be as follows:

| | | |
|---|---|---|
| Framework | : | Steel section posts and rails with [polyester powder coating] finish on exposed surfaces |
| Panels | : | Partition panel units shall be 83mm thick, insulated with 40 Kg. density mineral wool, factory assembled into complete individual panel units. Panel faces shall be minimum 1mm galvanized steel with internal horizontal reinforcements welded to back face of panel to assure flatness and uniform thickness. Lower panel on solid glass units shall have top edge formed to receive glass. Finish steel panels with [polyester powder coating]. |
| Acoustic Attenuation | : | 37.9-47.6 for solid panels and 41.2-41.5 for double glazed units |
| Flame spread | : | Class 0 |
| Fire resistance | : | 1 hour for solid panels |
| Glass | : | double glazing to partitions as manufacturers standards: Outer 8 mm, inner 6 mm |
| Doors and Frames | : | Hollow core flush doors finished with **(VAR)** and hung in steel door frame. |

Man: Unilock Ltd. (http://www.unilockproducts.com/)
Man: Clestra Hauserman (http://www.clestra.com/_multimed/accueil_swf_uk.htm)

or other equal and approved.

K41:X FIXINGS AND ACCESSORIES

X110 FASTENINGS: to be same metal as item being fixed with matching coating or finish and supplied by manufacturer of composite item unless otherwise specified.

X250 SELF-TAPPING SCREWS: to BS 4174 and BS EN ISO 1479.

X280 MACHINE SCREWS AND NUTS: to BS 4183 and BS EN ISO 1580 /7045.

X310 BOLTS, SCREWS AND NUTS: to BS 4190.

X510 DOWELS: mild steel, 10 mm diameter, 100 mm long, galvanized to BS EN ISO 1461 after fabrication.

X550 CRAMPS: mild steel, 25 x 3 x 250 mm girth, turned up at one end and twice drilled for 3 mm screws, fish-tailed at other end for building in and galvanized to BS EN ISO 1461 after fabrication.

X610 PLUGS: either traditional hardwood plugs, shaped to twist and grip when driven, or proprietary fibre or plastics plugs, or other approved type.

WORKMANSHIP

K41:1 FIXING

1101 STORAGE: do not deliver to site materials which cannot be immediately unloaded into suitable conditions of storage. Unload, handle and store materials to manufacturer's recommendations.

1201 PROTECTION:

prevent distortion of materials during transit, handling and storage

prevent damage to arrises, projecting features and surfaces exposed in finished work

prevent contact with mud, ashes, plaster and cement
retain protective coverings in place for as long as practicable and keep dry.

1211 CORROSION PROTECTION: before fixing apply two coats of bitumen solution or mastic impregnated tape to surfaces of aluminium components in contact with other surfaces.

1251 PRIMING AND SEALING: before fixing woodwork ensure that surfaces of wood which will be inaccessible after installation are primed or sealed.

1301 PLUGGING: locate plugs accurately. Use proprietary plugs in accordance with manufacturer's recommendations. When plugging through applied finishes ensure plugs have ample penetration into structural backing.

1351 FIXING: position work accurately, plumb, level and aligned as necessary. Fix securely to prevent pulling away, deflection or other movement during use and ensuring compliance with design and performance requirements. Do not distort work when tightening fixings. Ensure adequate clearance of opening parts.

1401 COMPLETION: check and adjust moving parts and ironmongery, lubricating as necessary to ensure correct functioning.

# K51 SUSPENDED CEILINGS

## GENERAL

### K51:A SCOPE

A105 SCOPE: this Section is for the specification of acoustic fibreboard, mineral fibreboard and metal suspended ceilings.

### K51:C SUBMITTALS

C105 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of the work as the Engineer may reasonably require.

C110 SAMPLES: submit representative samples of all component materials and products for each of type suspended ceiling proposed to be used. Obtain approval of appearance and other characteristics before placing orders. Ensure that delivered materials match samples.

C115 CONTROL SAMPLES: for each type of ceiling erect an area of finished work not less than 10 m2 in an approved location and obtain approval of appearance before proceeding.

C120 Mockups: Build mockups to verify selections made under Sample submittals and to demonstrate aesthetic effects and qualities of materials and execution.

Build mockups of typical suspended ceiling, complete, as shown on Drawings.

Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

### K43:D GUARANTEE

D105 General Guarantee: The special guarantee specified in this Article shall not deprive Employer of other rights Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

D110 Guarantee: Provide complete warranty in which Manufacturer, Contractor and Installer are jointly and severally responsible and agree to repair or replace without limitations, all or any part of suspended ceilings that fail in materials, finishes or workmanship within specified warranty period. Failures include, but are not limited to, the following:

Deterioration of metals, metal finishes, and other materials beyond normal weathering.

Discoloration of ceiling tiles or panels

Structural failures including, but not limited to, excessive deflection.

Warranty Period: Five years from date of Substantial Completion.

## MATERIALS AND PRODUCTS

### K51:X SYSTEMS AND ACCESSORIES

X105 GENERALLY: systems are to be fully integrated with the mechanical and electrical installations, including the provision of additional hangers, framing etc. and are to be supplied complete with manufacturers' standard edge trims, accessories, connectors, fixing clips and fixings.

X450 STEEL PANEL SUSPENDED CEILINGS: comprising micro-perforated galvanised steel panels with square edges, 600 mm x 600 mm size, 1-mm thick, flat surface and polyster powder coated finish, with acoustic pads. Secure with snap-in clips to suspension system. Panels are to be removable at any point in the ceiling.

Suspension system is to be concealed grid of of galvanised steel tee sections with enamelled finish, secured to steel main runners fixed to suspension rods or wires secured to structural ceiling and to include all hangers, fixings, main runners, cross members, primary channels, perimeter trims, splines, noggings, clips, bracing, bridging, etc., which are necessary to complete the installation and achieve the performance specified.

X550 CAVITY FIRE BARRIERS: asbestos-free, noncombustible board based on exfoliated vermiculite bonded with inorganic binders:

fire resistance : to BS 476- 20, 21 and 23

integrity/insulation : 120 minutes

Man: Thermax
Ref: Thermax non combustible boards

or other equal and approved.

X560 SOUND BARRIERS:

Material: rockwool slabs of 200 kg/m3 density. Refer to Section J21

X910 FASTENINGS: types and sizes recommended for particular purpose by ceiling manufacturer. Where none are recommended, types and sizes are to be approved. Non-ferrous or rust-proof types are to be used in areas of high humidity.

WORKMANSHIP

K51:1 GENERALLY

1051 SUSPENDED CEILINGS GENERALLY: unless otherwise specified, comply with the relevant recommendations and performance requirements of BS EN 13964 for the selection and assembly of components and materials.

1301 CONDITIONS: do not install suspended ceiling material until building is weathertight, wet trades have finished their work and services are above level of ceiling are complete. Before, during and after installation maintain temperature and humidity at levels similar to those which will prevail after building is occupied.

1401 CONDITIONING: before fixing, store ceiling tiles materials on site for at least 48 hours in conditions similar to those which will prevail after building is occupied. Ensure free circulation of air to surfaces.

1501 COORDINATION: co-ordinate the work of this Section with that of other trades to ensure that:

related works within ceiling voids: electrical and mechanical services, partitions, fire barriers, fire stopping, painting and the like; are at a suitable stage of completion to enable ceiling installation to proceed without damage or disfigurement to the ceiling system

fixtures around which the ceiling is to be installed are completed and that services, fire barriers and the like are in the correct position relative to the ceiling grid

hangers do not press against services or fittings and are installed vertically. Where obstructions prevent vertical installation ensure that hangers are braced against lateral movement or provide rigid bridging structures across obstructions

services integrated within the suspended ceiling are positioned accurately, supported adequately and aligned and levelled in relation to the ceiling tiles and suspension system.

## K51:2 ERECTING SUSPENDED CEILINGS

2051 QUALITY OF WORK: handle, store and fix suspended ceiling materials and accessories in accordance with manufacturers' recommendations and BS EN 13964 , ensuring compliance with design and performance requirements.. Set out accurately to give level soffits free from undulations and lipping with lines and joints straight and parallel to walls unless specified otherwise.

2101 SETTING OUT: where not shown otherwise set out ceilings to ensure that edge tiles are never less than half in width or length. Position grid to suit tile sizes, allowing for permitted deviations from nominal sizes.

2151 IRREGULAR SPACES: where surrounding walls or other building elements and features to which suspended ceiling relate are not square, straight or level obtain instructions on setting out.

2201 JOINTS IN GRID MEMBERS: position at points of contraflexure unless recommended otherwise by grid manufacturer or method of jointing is such that grid member acts as a continuous beam.

2251 DEFLECTION of suspension grid members between supports is to be not more than 3 mm.

2301 ACCESS PANELS: agree types, sizes and positions with the Engineer before commencing suspended ceiling installations.

2351 OPENINGS IN SUSPENDED CEILING MATERIALS are to be formed accurately and neatly to suit sizes and edge details of fittings, using methods recommended by the manufacturer and without causing damage or distortion.

2401 FIRE RESISTING CEILINGS: provide suitable means of accommodating expansion due to temperature increase in a fire. Expansion allowance per unit length is to be not less than that used in relevant fire test of ceiling system. Seal gaps around pipes, ducts etc. passing through ceiling, with tightly packed mineral fibre.

2451 FIRE STOPPING: seal any gaps at junctions of ceiling with walls, cavity barriers, ducts, pipes, etc., with mineral wool or other approved material to prevent penetration of smoke and flame.

2551 WIRE HANGERS: install vertically and ensure that:

hangers are carefully straightened before use, installed without bends or kinks and do not press against any fittings within the void

hangers are tied at top and bottom with tight bends to loops to prevent any vertical movement.

2651 INSULATION to be fitted accurately and firmly with no gaps so that specified performance levels are achieved. Ensure that:

insulation within individual tiles, trays, etc., is fitted closely and secured to prevent displacement when tiles are installed or subsequently lifted. Reseal any cut dustproof sleeving

insulation is laid out over the ceiling tiles in the widest practical widths to suit spacings of grid members, with closely butted joints

electrical cables are not covered and insulation is cut carefully around electrical fittings and the like

on sloping and vertical areas of ceiling, fastenings are used to prevent displacement.

2661 CAVITY FIRE BARRIERS: unless otherwise indicated, install barriers to subdivide the ceiling void into areas not exceeding 6 m2:

fit tightly and fix securely at perimeters and joints, using methods recommended by the barrier manufacturer, including steel support sections as appropriate. Ensure permanent stability and continuity with no gaps to achieve the performance specified

seal any gaps at junctions of cavity barriers with suspended ceiling, structural soffit, walls, ducts, pipes, etc. using mineral wool or other approved material to prevent penetration of smoke and flame

ensure that fixing to ceiling does not impair free expansion of grid system or otherwise affect fire resisting performance.

2701 SOUND BARRIERS:

align accurately with partition heads. Fit tightly and fix securely at perimeters and joints, using methods recommended by the barrier manufacturer, including steel

support sections as appropriate. Ensure permanent stability and continuity with no gaps

seal any gaps at junctions of sound barriers with partition heads, suspended ceiling, structural soffit, walls, ducts, pipes, etc. using mineral wool or suitable sealants.

2801 PROTECT suspended ceilings from damage and dirt. Ensure ceiling tiles materials are handled carefully and kept clean if subsequently removed for access to services, for inspection or remedial work.

# M11 METALWORK GENERALLY

## GENERAL

### M11:A SCOPE

A105 SCOPE: this Section is for the specification of metal materials, fastenings, finishings and workmanship, including components which form part of the construction and fabrication of composite products included in other Sections of the Specification.

### M11:C SUBMITTALS

C105 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of metalwork as the Engineer may reasonably require including elevations, plans and full size sections, proposed methods of fixing, proposed methods of forming joints and any proposals for fabricating large components in more than one piece.

C110 SAMPLES: submit material samples for each item of metalwork together with exposed finishes to be used in the work. Obtain approval of material, appearance and other relevant characteristics before proceeding with manufacture or delivery.

C115 SAMPLES: within the programmed time submit samples of the specified products, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

C 120 Special Warranty for Metal Finishes: Provide written warranty signed by Contractor and backed up by coating Manufacturer in which the contractor agrees to repair finishes that fail in materials or workmanship within specified warranty period. Failures include, but are not limited to, the following:

Peeling.
Chalking.
Crazing.
Fading.
Color retention.

C1215 Warranty Period for Metal Finishes: 10 years from date of Substantial Completion.

## MATERIALS AND PRODUCTS

## M11:D MATERIALS GENERALLY

D205 MATERIALS GENERALLY: grades of metals, section dimensions and properties are to be to the appropriate British Standard or other technically equivalent standard as approved by the Engineer. When not specified, select grades and sections appropriate for purpose and application.

## M11:H SECTIONS

H105 RECOMMENDED METRIC SIZES of ferrous and non-ferrous wires, bars and flat products to be to BS 6722.

H205 HOT-ROLLED MILD STEEL SECTIONS except equal and unequal angles: to BS 4 -1, made from weldable structural steel to BS EN 10025 1>6.

H210 HOT-ROLLED MILD STEEL HOLLOW SECTIONS: to BS EN10210-1-2, made from steel to BS 7668.

H215 COLD-ROLLED MILD STEEL HOLLOW SECTIONS: welded cold formed hollow sections to BS EN 10219-2, made from weldable structural steel to BS EN 10025-1.

H220 HOT-ROLLED MILD STEEL ANGLES: to BS EN ISO 1461, made from weldable structural steel to BS EN 10025 1>6.

H225 MILD STEEL BARS: to BS 6722 made from weldable structural steel to BS EN 10025 1>6.

H250 COLD-ROLLED STEEL SECTIONS: to BS EN 10162, made from steel to BS 1449-1.1

H255 GALVANIZED COLD-ROLLED STEEL SECTIONS: to BS EN 10162, made from steel to BS EN 10327, BS EN 10143 and BS EN 10236.

H260 STEEL TUBES: cold-formed steel tubing to BS EN 10305-1 (seamless), EN 10305-2 (welded); or to ASTM A 500 .

H262 STEEL TUBES: hot-formed steel tubing to BS EN 10296-1 (welded), BS EN 10297-1 (seamless); or to ASTM A 501.

H270 STAINLESS STEEL TUBES: to BS EN 10296-2 or ASTM A 269, grade 304 S16 for internal use and grade 316 S16 for external use. In welded tubes the weld is to be inconspicuous.

H280 ALUMINIUM ALLOY BARS, EXTRUDED ROUND TUBE AND SECTIONS: wrought aluminium and aluminium alloys for general engineering purposes - bars, extruded round tube and sections to BS EN 515, BS EN 573-3, BS EN 12020-1 & 2. Alloy and temper shall be recommended by aluminum manufacturer for strength, corrosion resistance, and application of required finish, but not less than 150-MPa ultimate tensile strength, not less than 110-MPa minimum yield strength, and not less than 1.6-mm thickness at any location for the main frame and sash members.

H290 ALUMINIUM ALLOY STRUCTURAL SECTIONS: to BS 1161 .

H310 BRASS EXTRUDED SHAPES: ASTM B 455, alloy UNS No.C38500 (architectural bronze).

M11:J PLATE, SHEET AND STRIP

J210 MILD STEEL PLATE: made from weldable structural steel to BS EN 10025-1> 6.

J215 STEEL PLATE AND SHEET: to BS 1449-1.1.

J220 GALVANISED STEEL PLATE, SHEET AND STRIP: to BS EN 10327 and BS EN 10143. Weight of zinc coating: 275 g/m2 (total both sides).

J225 STAINLESS STEEL PLATE, SHEET AND STRIP: to BS EN ISO 9445, grade 304 S16 for internal use, grade 316 S16 for external use.

J230 STAINLESS STEEL BARS AND SHAPES: to ASTM A 276, grade 304 S16 for internal use, grade 316 S16 for external use.

J250 ALUMINIUM ALLOY PLATE, SHEET AND STRIP: to BS EN 485- 1 to 4 and BS EN 515.

M11: K MESH

K310 STEEL EXPANDED MESH: made from sheet to BS 1449-1.1.

K350 ALUMINIUM ALLOY EXPANDED MESH: to BS EN 485-1 - 4 and BS EN 515, grade S1C.H4.

K390 MESH FOR INSECT SCREENS: aluminium alloy fine wire, 0.42 mm mesh.

M11:X FASTENINGS AND FIXINGS

X115 FASTENINGS: to be to the appropriate British Standard or other technically equivalent standard as approved by the Engineer and of matching metal and finish as the item being fixed. Unless otherwise specified fastenings are to be supplied by the manufacturer of the component or product.

X215 ALUMINIUM SCREWS: to BS 1473, alloy 2014 A fully heat treated.

X250 STAINLESS STEEL SCREWS: made from austenitic stainless steel to BS EN 10088, designation 304 S15.

X310 BOLTS, SCREWS AND NUTS: to BS 4190 .

X320 MACHINE SCREWS AND NUTS: to BS EN ISO 1580 & BS EN ISO 7045

X410 SELF-TAPPING SCREWS: to BS 4174 and BS EN ISO 1479.

X510 ALUMINIUM RIVETS: to BS 1473 and BS 4620.

X910 PLUGS: proprietary fibre or plastics plugs or other approved type.

M11:Y FINISHINGS, COATINGS AND JOINTING MATERIALS

Y210 CADMIUM AND ZINC PLATING of iron and steel surfaces are to be to BS EN ISO 2081 and 2082.

Y230 NICKEL PLATING: to BS EN 12540, of suitable service condition.

Y250 CHROMIUM PLATING: to BS EN ISO 1456, of suitable service condition and with satin finish.

Y315 GALVANISING: hot dip galvanized coatings on fabricated iron and steel articles. to BS EN ISO 1461. Weight of zinc coating, unless otherwise specified to be Z180 hot-dip galvanized corrosion resistant coating.

Y320 GALVANISING: hot dip to BS EN 10327, 10143 and BS EN 10236 or ASTM A 653M. Weight of zinc coating, unless otherwise specified to be Z180 hot-dip galvanized corrosion resistant coating.

Y410 SHERARDIZING: to BS 4921, class 1 for external use and class 2 for normal internal use.

Y510 ZINC SPRAYING of iron and steel surfaces is to be to BS EN ISO 2063.

Y520 ALUMINIUM SPRAYING of iron and steel surfaces is to be to BS EN ISO 2063.

Y550 VITREOUS ENAMELLING of steel surfaces is to be to BS EN 14431.

Y610 ANODISING OF ALUMINIUM ALLOYS: to BS 3987 and BS EN 12373-1 or AAMA 611, of thickness grade suitable for service condition , with approved satin finish on exposed surfaces. Anodised finish is to have the following properties:

thickness grade : as indicated by Engineer.

colour : clear anodised

Obtain certification from anodiser that thickness of coating suitable for service condition has been applied and submit to the Engineer.

Y660 POLYESTER POWDER COATING (PE-F) for galvanised steel and aluminium alloy components is to be approved type to meet the requirements of AAMA 2603 or BS 6496 and BS EN 13438 consisting of powder particles of resinous material and additives to improve performance. The coating is to be electrostatically sprayed on the object to produce produces a hard, durable coating:

surface finish : satin

minimum dry film thickness : 80 microns

Y710 POLISHED STAINLESS STEEL: surfaces visible in completed work are to be polished with fine grit to produce a uniform, directionally textured polished finish to approval.

Y810 ADHESIVES for bonding metal to metal and metal to wood are to be recommended by their manufacturers for the particular surfaces and conditions of use.

Y850 BITUMEN COATING SOLUTION: to BS 3416, Type 1 and BS 6949 for cold application.

Y856 POINTING SEALANT: one-part silicone sealant to BS EN ISO 11600, or ASTM C 920.

Man: Dow Corning
Ref:795

Man: Tremco
Ref:Tremsil 500

or other equal and approved.

WORKMANSHIP

M11:1 FABRICATING GENERALLY

1101 QUALITY OF WORK: fabricate metalwork carefully and accurately to ensure compliance with design and performance requirements using types, grades and sections of metal appropriate for the purpose. Finished work must be free from distortion and cracks. Use proprietary products to manufacturer's recommendations.

1151 PRE-FINISHED METAL may be used if:

finish complies with specified requirements

methods of fabrication do not damage or alter appearance of finish

finish is protected during fabrication.

1162 DISSIMILAR METALS: components made of dissimilar metals, when in contact, are to be protected in accordance with BS PD 6484 and as directed by the Engineer.

1201 COLD FORMED WORK: to be free from warping, buckling and fractures. Form bends with a brake press or by cold rolling.

1251 CORNERS: mitre junctions of identical sections unless otherwise specified.

1261 HOLES: form without distortion of surrounding metal.

1271 MOVING PARTS when assembled must move freely and without binding.

1301 CLEANING: remove burrs and sharp arrisses which would be visible after fixing or a hazard to the user.

1351 STAINLESS STEEL: grind off materials liable to corrode after thermal cutting.

1401 ADHESIVE BONDING:

prepare surfaces of metals to receive adhesives by degreasing and abrading mechanically or chemically

use adhesives in accordance with manufacturer's recommendations

form bond under pressure.

1501 MECHANICAL JOINTS: to be tight with no visible gaps. Unless otherwise specified use countersunk machine screws where screw heads will be visible after item is fixed and where raised screw heads would interfere with moving parts. Joints of items located externally are to be bedded in compound including mating surfaces, cleats and other fixings.

1601 APPLYING COATINGS: apply coatings to metal work only by applicators licensed by the coating manufacturer.

prepare substrates and apply finishes in strict accordance with Manufacturer' printed instructions and by applicators licensed by the coating manufacturer.
apply after fabrication is complete and fixing holes have been drilled

before applying coating remove paint, grease, flux, rust, burrs and sharp arrisses

make good defects which would show after application of coating and finish surfaces smooth.

## M11:2 WELDING AND BRAZING

2101 PREPARATION: remove dirt, grease, moisture and oxide from edges to be welded. Remove scale and residue from arc and power cutting by machining or hand grinding.

2151 ACCURACY:

ensure accurate fit using clamps and jigs where practical

use tack welds for temporary attachment only, unless otherwise specified and where jigging is not practical.

2201 WELDS: make joints with parent and weld metal fully fused throughout with no inclusions, holes, porosity or cracks.

2251 TESTING: when required submit samples of welding to an approved laboratory for testing to appropriate BS or as required by the Engineer.

2351 SPATTER: prevent weld spatter falling on surfaces of self-finished materials visible in completed work.

2401 RESIDUES: ensure complete removal of flux residues and slag.

2451 BUTT WELDS visible in completed work are to be finished smooth and flush with adjacent surfaces.

2501 WELDING OF STEEL: to be by one of the following:

metal arc welding to BS EN 1011-2 for mild steel

projection welding to BS EN 28167

seam welding to BS EN ISO 16433 for mild steel sheets

other methods subject to approval.

2551 WELDING OF STAINLESS STEEL: to BS EN 1011-3 or other methods, subject to approval. Use double bevel butt welds, backing bars to remove heat, jigging, tack welds and other measures necessary to minimise distortion. Remove slight distortion by light hammering taking care not to damage surface finish.

2601 WELDING OF ALUMINIUM ALLOYS: to be by one of the following:

TIG welding to BS EN 1011-4

MIG welding to BS EN 1011-4

other methods subject to approval.

2701 BRAZING: to BS EN 14324.

M11:3 FIXING GENERALLY

3101 STORAGE: do not deliver to site metalwork which cannot be immediately unloaded into suitable conditions of storage. Unload, handle and store metalwork to manufacturer's recommendations.

3201 PROTECTION:

prevent distortion of metalwork during transit, handling and storage

prevent damage to arrises, projecting features and surfaces exposed in finished work

prevent contact with mud, ashes, plaster and cement

retain protective coverings in place for as long as practicable and keep dry.

3211 CORROSION PROTECTION: before fixing apply two coats of bitumen solution or mastic impregnated tape to surfaces of aluminium components in contact with other surfaces.

3251 PROTECTION: a 3 mm neoprene strip packing is to separate all aluminium joinery elements from steel frames or other elements that may corrode aluminium.

3301 PLUGGING: locate plugs accurately. Use proprietary plugs in accordance with manufacturer's recommendations. When plugging through applied finishes ensure plugs have ample penetration into structural backing.

3351 FIXING: position and maintain metalwork plumb, level and square. Fix securely to prevent pulling away, deflection or other movement during use. Do not distort metalwork when tightening.

3401 LOADING: do not use railings or balustrades as strutting or supports after fixing.

3501 WELDING ON SITE: do not braze or solder on site without approval.

# M12 WOODWORK GENERALLY

## GENERAL

### M12:A SCOPE

A105 SCOPE: this Section is for the specification of wood materials, fixings, finishes and workmanship, including components which form part of the construction and fabrication of composite products included in other Sections of the Specification.

### M12:C SUBMITTALS

C105 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of woodwork as the Engineer may reasonably require including elevations, plans and full size sections, proposed methods of fixing, proposed methods of forming joints and any proposals for fabricating large components in more than one piece.

C110 SAMPLES: submit material samples for each item of woodwork together with exposed finishes to be used in the work. Obtain approval of material, appearance and other relevant characteristics before proceeding with manufacture or delivery.

C115 SAMPLES: within the programmed time submit samples of the specified products, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

C120 PRODUCT DATA: provide data for each type of process and factory-fabricated product. Indicate component materials and dimensions and include construction and application details. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used, net amount of preservative retained, and chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material.

MATERIALS AND PRODUCTS

M12:H WOOD

H110 SOFTWOOD FOR FRAMING, BATTENS AND THE LIKE: to be free from decay and insect attack, except pinhole borers, with no knots wider than half the width of the section, and with tolerances of +3 mm and -5 mm on specified sizes.

H120 SOFTWOOD SPECIES FOR JOINERY: to BS EN 942. Softwood species for joinery to be used in external locations are to be the species recommended for that purpose.

H130 HARDWOOD SPECIES FOR JOINERY: to BS EN 942. Hardwood species for joinery to be used in external locations are to be the species recommended for that purpose.

H150 SURFACES OF WOOD: to BS EN 942, exposed surface category where not concealed or semi-concealed after installation.

H155 PRESERVATIVE TREATMENT: organic solvent as British Wood Preserving and Damp-proofing Association Commodity Specification C5. Preservative chemicals to be the types acceptable to Engineer :

Chromated Copper Arsenate (CCA).
Ammonical copper zinc arsenate (ACZA) for treatment of Douglas Fir.

Application: by High pressure

Moisture content of timber at time of treatment shall be not more than 28%. Allow timber to dry for at least 14 days before use.

H160 FIRE-RETARDANT TREATED MATERIALS: specify fire-retardant treatment by reference to (AWPA) American Wood Preservers' Association where fire-retardant treated materials are indicated, provide materials that comply with performance requirements in AWPA C20 (lumber) and AWPA C27 (plywood). Identify fire-retardant treated wood with appropriate classification marking of UL, U.S. Testing, Timber Products Inspection, or another testing and inspecting agency acceptable to authorities having jurisdiction.

use treatment for which chemical manufacturer publishes physical properties of treated wood after exposure to elevated temperatures, when tested by a qualified independent testing agency according to ASTM D 5664, for lumber and ASTM D 5516, for plywood
use treatment that does not promote corrosion of metal fasteners

use exterior type for exterior locations and where indicated

mill lumber before treatment and implement special procedures during treatment and drying processes that prevent lumber from warping and developing discolorations from drying sticks or other causes, marring, and other defects affecting appearance of treated woodwork

kiln-dry material before and after treatment to levels required for untreated material

for exposed items indicated to receive a stained or natural finish, use chemical formulations that do not bleed through, contain colorants, or otherwise adversely affect finishes.

## M12:J RIGID SHEETS

J210 PLYWOOD: to BS EN 636, face grade 2 for general use and grade 1 for clear finish. Bonding is to be to BS 1203, type WBP for external use and type MR or INT for internal use.

J220 MARINE QUALITY PLYWOOD: to BS 1088-1-2, excluding plywood made from gaboon.

J230 WOOD CHIPBOARD (Particle Board): to BS EN 312

J240 BLOCKBOARD/LAMINBOARD: Composite boards having a core made up of strips of wood each not more than 30 mm wide, laid separately and glued or otherwise joined together to form a slab, to each face of which is glued one or more veneers with the direction of the grain of the core strips running at right angles to that of the adjacent veneers.

Two types of blockboard and laminboard are generally available:-

3-ply construction: has core slabs sandwiched between one, usually thick, veneer on each face. The result is a relatively low grade panel in terms of both appearance and strength properties.

5-ply construction: has core slabs sandwiched between two veneers on each side. Usually the inner veneers are ‘core’ or low grade veneers and the outer veneers are high quality utility veneer or decorative veneer.

J250 CORK BOARD: to BSEN 12104.

J258 MEDIUM-DENSITY FIBERBOARD (MDF): product made without formaldehyde and complying with ANSI A208.2, Product Class MD.

J260 LAMINATED PLASTICS SHEET VENEERS: thin single faced laminates to BS EN 438-1>5, type and index suitable for intended use. Colour or pattern to be selected by the Engineer.

J265 LAMINATED PLASTICS COMPACT PANELS: 18mm thick faced laminates to BS EN 438, type and index suitable for intended use. Colour or pattern to be selected by the Engineer.

J270 WOOD VENEER: Oak, unless otherwise selected by Engineer, free from decay and wormholes and obtained from an approved supplier.

J280 BUILDING BOARD: moisture and fire resistant fibre reinforced composite panels made of calcium silicate matrix reinforced with asbestos-free selected fibers and fillers, semi compressed and cured in high pressure steam autoclave.

Man: Promat UK Ltd. [http://www.promat.co.uk/]
Ref: Masterboard

or other equal and approved.

J285 SOLID PLASTIC BOARD (CORIAN): monolithic, hard, non-porous sheets made of homogeneous thermoset polymer alloy of acrylic and polyester resins with mineral fillers. Sheets are to be highly resistant to impact, scratches and stains.

Man: DuPont de Nemours [http://www.corian.com/corian/]
Ref: Corian

or other equal and approved.

J290 LINOLEUM SHEET: to BS EN 12104, plain, with natural finish.

## M12:X FIXINGS AND ACCESSORIES

X110 NAILS: to BS 1202- 1, 2 or 3 generally, but non-ferrous types to Parts 2 or 3 for external use.
X210 WOOD SCREWS: to BS 1210 generally, but non-ferrous types for external use.

X250 SELF-TAPPING SCREWS: to BS 4174 / BS EN ISO 1479 and BS EN ISO 7049.

X510 DOWELS: mild steel, 10 mm diameter, 100 mm long, galvanized to BS EN ISO 1461 after fabrication.

X550 CRAMPS: mild steel, 25 x 3 x 250 mm girth, turned up at one end and twice drilled for 3 mm screws, fish-tailed at other end for building in and galvanized to BS EN ISO1461 after fabrication.

X610 PLUGS: either traditional hardwood plugs, shaped to twist and grip when driven, or proprietary fibre or plastics plugs, or other approved type.

M12:Y TREATMENTS, ADHESIVES AND FINISHES

Y110 PRESERVATIVE TREATMENT for wood is to be type listed in BS 1282 (except coal tar creosote), obtained from an approved manufacturer, to give suitable protection against termites and other wood destroying organisms.

Y115 FIRE RETARDANT TREATMENT: organic-resin exterior type formulation complying with treatment standards (AWPA C20 for lumber, AWPA C27 for plywood) by the American Wood-Preservers' Association (AWPA). Flame spread of either 25 or less or 75 or less.

Y210 ADHESIVES FOR JOINERY: close contact type to BS EN 301 or BS EN 302 as applicable for suitability of particular purpose, application and use. Obtain manufacturer's confirmation that adhesive is compatible with preservative treatment.

Y310 SEALER FOR END GRAIN:

joinery with clear finishes : clear end grain sealer

joinery with paint finishes : aluminium paint.

## WORKMANSHIP

### M12:1 GENERALLY

1051 STANDARD: work in this Section is to be executed generally in accordance with BS 1186-2 & 3 and BS 8000-5.

1401 MOISTURE CONTENTS of wood and wood based sheets are to be suitable for location and purpose for which they are to be used in the works and within a range which can be maintained during construction and service.
1402 MOISTURE CONTENTS: during storage, fixing and thereafter to substantial completion, maintain conditions of temperature and humidity to suit moisture contents of wood components.

### M12:2 MACHINING AND ASSEMBLING

2101 QUALITY OF WORK:

make woodwork as specified and to BS 1186- 2

form sections out of the solid when not otherwise specified; carefully machine wood to accurate lengths and profiles free from twist and bowing; after machining surfaces are to be smooth and free from tearing, woolliness, chip bruising and other machining defects

assemble with tight, close fitting joints to produce rigid components free from distortion and within specified tolerances

nail heads which will be visible in completed work are to be punched below surfaces of timber

screw heads are to be countersunk not less than 2 mm below timber surfaces which will be visible in completed work; all screws are to have clearance holes; screws of 8 gauge or more and all screws into hardwood are to have pilot holes.

2151 FABRICATION

Sections: Accurate in profile and length, and free from twist and bowing. Formed out of solid unless shown otherwise.

Machined surfaces: Smooth and free from tearing, wooliness, chip bruising and other machining defects.
Joints: Tight and close fitting.

Assembled components: Rigid. Free from distortion.

Screws: Provide pilot holes.

Screws of 4 mm diameter or more and screws into hardwood: Provide clearance holes.

Countersink screws: Heads sunk at least 2 mm below surfaces visible in completed work.

Adhesives: Compatible with wood preservatives applied and end uses of timber.

2201 CROSS SECTION DIMENSIONS OF TIMBER:

General: Dimensions on drawings are finished sizes.

Maximum permitted deviations from finished sizes:
Softwood sections: To BS EN 1313-1:-
Clause 6 for sawn sections.
Clause NA.2 for further processed sections.
Hardwood sections: To BS EN 1313-2:-
Clause 6 for sawn sections.
Clause NA.3 for further processed sections.

2251 TOLERANCES: make woodwork to the sizes shown on the Drawings subject to the following tolerances:

| | | |
|---|---|---|
| straightness in each 8 m (non cumulative) | : | +/-5 mm |
| length up to 2 m | : | +/-3 mm |
| squareness of frames and linings | : | 1 mm in 500 mm |
| clearance between door leaf and frames | : | 2 mm (+1 mm, -0.5 mm). |

2301 PRESERVATIVE TREATMENT:

application is to be carried out after cutting and machining, but before assembly, by a processor licensed by the treatment solution manufacturer

solution strengths and treatment by pressure, vacuum or immersion process are to be selected to achieve service life and to suit wood treatability
moisture content of wood at time of treatment is to be as specified for use in the work

after treatment, allow wood to dry before use

for each batch of wood, provide certificate of assurance that treatment has been carried out as specified.

2351 PRESERVATIVE TREATED WOOD:

re-treat all treated wood which is sawn along the length, ploughed, thicknessed, planed or otherwise extensively processed

treat wood surfaces exposed by minor cutting and drilling with two flood coats of solution recommended for the purpose by the treatment solution manufacturer.

2401 ADHESIVES: use in accordance with manufacturer's recommendations.

2501 SURFACE FINISH: sand woodwork to give smooth, flat surfaces suitable to receive specified finish. Arrises are to be pencil rounded.

2601 SEAL exposed end grain of woodwork before general sealer or primer is applied.

2651 PRIMING AND SEALING: woodwork to receive clear finish or paint is to be sealed or knotted and primed, as described in Section V11 of the Specification, before leaving the joinery shop.

2701 LAMINATED PLASTICS SHEET VENEERS:

Fabrication: To British Laminated Plastics Fabricators Association Ltd (BLF) fabricating standards.

condition sheets before bonding

when not otherwise specified, apply to the reverse side of flat boards a balancing veneer of similar construction to the decorative veneer and from the same manufacturer

bond in presses whenever possible

finished components are to be free from bow, twist, scratches, chipping, cracks, pimpling, depressions, glue spill, staining, defects in colour and pattern and the like joints exposed to view in finished work are to be tight butted and true with no lipping; chamfer edges at external angles.

2751 WOOD VENEERS:

condition core material and veneers before bonding

when not otherwise specified, apply to the reverse side of flat boards a balancing veneer with the same moisture and temperature movement characteristics as the facing veneer

set out veneers so that features and pattern are aligned and in regular, uniform symmetry, unless specified otherwise

bond in presses whenever possible

finished components are to be free from defects, including bow, twist, scratches, chipping, pimpling, blebs, depressions, glue spill, staining, staining and the like

edges of veneers are to be tightly butted, with no gaps or other open defects and no lipping; sand to a fine, smooth finish free from sanding marks.

Tolerance of veneer thickness (maximum): ± 0.5 mm.

Surface finish: Fine, smooth, free from sanding marks.

2801 FINISHING

Surfaces: Smooth, even and suitable to receive finishes.

Arrises: Eased unless shown otherwise on drawings.

End grain in external components: Sealed with primer or sealer as section M60 and allowed to dry before assembly.

M12:3 FIXING

3101 STORAGE: do not deliver to the site woodwork which cannot be immediately unloaded into suitable conditions of storage. Unload, handle and store woodwork to manufacturer's recommendations.

3151 STACKING: stack woodwork on bearers on level dry floors under cover. Stagger components or separate with spacers to prevent damage by and to projecting ironmongery, beads etc. Stack doors horizontally on not less than three level bearers at not more than 1 m centres.

3201 PROTECTION:

prevent distortion of woodwork during transit, handling, storage and fixing

keep woodwork clean and dry before fixing; retain coverings in position for as long as required.

prevent damage to woodwork and marking of surfaces which are to be visible in the completed work

provide additional protection as necessary and remove temporary coverings on completion.

3301 PRIMING AND SEALING: before fixing woodwork ensure that surfaces of wood which will be inaccessible after installation are primed or sealed as specified.

3401 FIXING: position woodwork accurately, plumb, level and aligned as necessary. Fix securely to prevent pulling away, deflection and other movement prevent damage to woodwork and marking of surfaces which will be visible in the completed work during use and ensuring compliance with design and performance requirements.

3451 DISTORTION:

do not distort woodwork when driving wedges or other packing or when tightening fixings

ensure adequate clearance of opening parts; if necessary adjust packing and fixings to eliminate binding

do not cut, plane or sand woodwork to remedy distortion.

3481 LOADING: woodwork is not to carry structural loads unless specifically designed to do so. Do not use balustrades or railings as strutting or supports after fixing.

3501 PLUGGING: locate plugs accurately. Use proprietary plugs in accordance with manufacturer's recommendations. When plugging through applied finishes ensure plugs have ample penetration into structural backing.

3551 NAIL FIXING: punch heads below surface of wood which will be visible in the completed work.

3561 SCREW FIXING:

all screws are to have clearance holes

screws of 8 gauge or more and all screws into hardwood are to have pilot holes about half the diameter of the shank

use purpose made plastics plugs when fixing to concrete or masonry

countersink screw heads not less than 2 mm below wood surfaces which will be visible in completed work.

3581 PELLETING: countersink screws heads 6 mm below wood surfaces which are to be clear finished. Glue in grain matched pellets not less than 6 mm thick and cut from matching wood. Finish off flush with face.

# M21 WINDOWS AND SCREENS

## GENERAL

### M21:A SCOPE

A105 SCOPE: this Section is for the specification of metal, wood and plastic windows, screens, louvres and the like including skylights, together with associated hardware, fixings, ironmongery, accessories and sealants; including:

aluminium windows and screens
skylights

### M21:C PERFORMANCE REQUIREMENTS

C105 GENERAL: provide glazed unit assemblies engineered, fabricated, and installed to withstand normal thermal movement, wind loading, and impact loading without failure, as demonstrated by testing manufacturer's standard units, representative of the types, grades, classes, and sizes required for the project according to test methods indicated.

C205 TEST CRITERIA: testing shall be performed by an approved qualified independent testing agency based on the following criteria:

design wind pressure for purposes of the following tests is the 'design wind speed' shown on Drawings, or specified or determined from the code, whichever is greater, as determined by Engineer.

C215 TEST PROCEDURES: test glazed unit assemblies according to:

BS 6375-1 Performance of windows: classification of weathertightness and guidance on selection and specification.
BS 6375-2 Performance of windows: specification for operation and strength characteristics
BS 6375-3 Performance of windows: classification for additional performance characteristics and guidance on selection and specification
BS EN 1026 for air permeability tests.
BS EN 1027 [ASTM E331] for water tightness tests.
BS EN 12211 for wind resistance tests.
BS 6375-2 for operation and strength characteristics.

C225 PERFORMANCE REQUIREMENTS: testing of glazed unit assemblies shall demonstrate compliance with:

weathertightness test pressure requirements indicated in BS 6375-1 for the exposure category classification applicable to the project

operation and strength characteristics specified in BS 6375- 2.

C230 STRUCTURAL PERFORMANCE: design, engineer, fabricate, and install the glazed window system including anchorage, and reinforcement where necessary, to withstand effects of wind load design pressures normal to the plane of the wall and design live loads, and accommodate deflections and movements without damage, when tested, with no material failures or permanent deformation of structural members.

Design wind pressure should be calculated in accordance with BS 6399-2 and BS 6262, or as per wind tunnel test for high rise buildings.

The design wind pressure for standard window systems to be derived from the maximum calculated wind pressure as follows (CWCT 'Standard for systemised building envelopes ' 2.2.4).

Do not change the aesthetic aspect of the design intent of the window as set by the architectural drawings.

Determine also the sizes and thicknesses of glass panes (refer to section R11) and panel/facings, the sizes types and locations of framing, fixings and supports, to ensure that the windows will resist all imposed loads, and accommodate all deflections and movements without damage.

- Design wind pressure: : 90 mph Exposure D

Seismic Loads: 2B.

Structural Test Pressure: shall be equal to 150 percent of the inward and outward acting design pressures.

Deflections: the window system shall be capable of accommodating structural support movements and weather exposures including but not limited to sway, twist, column shortening and long-term creep and deflection; and of performing within the following limitations under the required design load, both positive and negative:

Perpendicular Deflection: deflection of framing members, measured perpendicular to wall plane, shall not exceed 1/175 of the unsupported span (defined as the distance between anchor centre lines) or 19 mm, whichever is less.

Parallel Deflection: when carrying the full dead load, deflection of framing members measured in a direction parallel to wall plane shall not exceed an amount that will reduce glass bite by less than 75 percent of the design dimension; nor reduce edge clearances to less than 25 percent of design dimension or 3 mm, whichever is greater.

C305 THERMAL MOVEMENTS: provide glazed unit assemblies that allow thermal movement resulting from the following maximum change (range) in ambient temperature without buckling, opening of joints, and overstressing of components, connections, and other detrimental effects. Base engineering calculation on actual surface temperatures of materials due to solar heat gain and nighttime sky heat loss:

temperature change (range): 67 deg. C, ambient; 100 deg. C, material surfaces.

M21:D SUBMITTALS

D105 SHOP DRAWINGS: submit shop drawings showing fabrication and installation of each type of window, screen and skylight required, include information not fully detailed in manufacturer's standard data, and the following:

layout and installation details, including anchors and fixings

elevations at 1:50 scale and typical window unit elevations 1:20 scale

full-size section details of typical composite members, including reinforcement, stiffeners and methods of jointing and connection

location of weep holes

ironmongery and hardware, including operators

window cleaning provisions

glass and glazing details

D110 CATALOGUES: submit manufacturer's catalogues and technical specifications for materials and products proposed to be incorporated into the works.

D115 MANUFACTURER'S DATA: submit manufacturer's installation instructions and pertinent data for each type of window, screen and skylight, including the following:

construction details and fabrication methods
profiles and dimensions of individual components

data on ironmongery, hardware, accessories, and finishes

recommendations for maintaining and cleaning exterior surfaces.

D140 TEST REPORTS: submit reports from an approved qualified independent testing agency certifying that each type, class and size of unit complies with performance requirements indicated. Test results based on use of down-sized test units will not be accepted.

D150 GUARANTEE: provide two copies of a written guarantee in a form acceptable to the Engineer which is signed by the manufacturer and the Contractor, undertaking to:

replace windows which fails in materials or workmanship within **five years** of the date of substantial completion. Failure of materials and workmanship shall include, but not be limited to: excessive air infiltration, water penetration or condensation; excessive deflections or deterioration in metal, other than due to normal weathering; and any defects in anchorage, sealants, fixings, accessories and other components of the work

repair or replace finishes or coatings which fail or become defective and defined to include abnormal deterioration, ageing or weathering.

Warranty Period: 15 years from date of Substantial Completion for electrostatically applied polyester powder coating.

M21:E <u>SAMPLES</u>

E105 SAMPLES: within the programmed time submit samples of the specified products, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

E106 MOCK-UPS: within the programmed time assemble a mock-up sample of the specified. Approved samples may be included in the finished work. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

mock-up to be complete and to include glazing, hardware and all necessary accessories.

M21:F DEFINITIONS

F105 Direction of Opening: on Architectural Drawings, the indications for direction of opening are as follows:

Fixed windows are indicated by letter "F"

Sliding windows are indicated by an arrow indicating the direction of slide.

Casement or pivoting windows are indicated by a dotted triangle, the vertex of which indicates the hinge or pivot side.

Dual action windows are indicated by two dotted triangle, the vertex of first shall indicate the hinge side, the the vertex of the second shall indicate the pivot side.

MATERIALS AND PRODUCTS

M21:G COMPONENTS

G105 METAL AND WOOD COMPONENTS of composite units, including fastenings, fixings, treatments, finishings, coatings and jointing materials are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

G110 ALUMINUM EXTRUSIONS: alloy and temper as recommended by aluminum window manufacturer for strength, corrosion resistance, and application of required finish, but not less than 150 MPa ultimate tensile strength, not less than 110 MPa minimum yield strength, and not less than 1.6 mm thickness at any location for the main frame and sash members.

G115 FASTENERS: fasteners for aluminium members shall be from aluminium, nonmagnetic stainless steel, epoxy adhesive, or other materials warranted by manufacturer to be noncorrosive and compatible with aluminum window members, trim, hardware, anchors, and other components. Cadmium-plated steel fasteners are not permitted.

M21:H1 METAL WINDOWS, SCREENS, AND THE LIKE

H110 ALUMINIUM WINDOWS AND SCREENS: to the general requirements of BS 4873 or ANSI/AAMA 101, constructed from extruded aluminium sections made from alloy 6063 fully heat treated. Windows are to be supplied complete with frames, sub-frames, mullions, transoms, sills, louvers, opening casements and insect screens, as shown on the Drawings, together with manufacturer's approved matching ironmongery, non-PVC

glazing beads and gaskets, weather strips, accessories and fixings. Bearing devices, hardware and reinforcing members are to be manufactured from material that is corrosion resistant and compatible with aluminium. Fasteners are to be made from cadmium plated or austenitic stainless steel 304 S15 or 316 S31. Weather-stripping are to be made from neoprene or EPDM rubber. Aluminium sections are to have electrostatically polyester powder coated finish, units may be pre-glazed or glazed on site in accordance with the requirements of Section R11 of the Specification.

Provide window units with thermally broken sections and a U-value maximum of 2.5 W/m2 °K at 24 km/h exterior wind velocity and a condensation resistance factor (CRF) of 50 when tested according to AAMA 1503.

Man: Graham Architectural Products Corporation [http://www.grahamarch.com/]
Man: Kawneer [http://www.kawneer.com/kawneer/north_america/en/home.asp]
Man: Schuco International [http://www.schueco.co.uk/]

or other equal and approved.

H130 SKYLIGHT: square shaped skylight comprising glass as specified in Section R11 “General Glazing”, type GC, with aluminium framing with polyester powder coating finish:

Aluminium Members: provide aluminium members of the alloy and temper recommended by the manufacturer to satisfy requirements for strength, corrosion resistance and application of finish indicated. Comply with requirements of ASTM B 221M for extrusions, ASTM B 209M for aluminium sheet or plate, and ASTM B 211M for aluminium bars, rods and wire:

1. Principal framing members: provide extruded aluminium members of 6063-T5 alloy and temper with a minimum thickness of 3 mm.

2. Trim members: provide extruded aluminium glazing caps and other miscellaneous non-supporting trim members of 6063-T5 alloy and temper with minimum thickness of 1.5 mm.

3. Formed metal members shall be sheet aluminium of 6061-T6 alloy and temper with a minimum thickness of 3 mm for structural members and 1.5 mm for closures and trim.

Steel Sections: provide hot-rolled structural shapes to fit framing sections, complying with ASTM A 36M.

Gaskets and Joint Fillers: provide manufacturer's standard permanent-type framing system gaskets and joint fillers for sliding joints, compression joint translation, or non-moving joints depending on joint movement and sealing requirements.

H160 FASTENERS: fasteners for aluminium members shall be from aluminium, nonmagnetic stainless steel, epoxy adhesive, or other materials warranted by manufacturer

to be noncorrosive and compatible with aluminum window members, trim, hardware, anchors, and other components. Cadmium-plated steel fasteners are not permitted**.**

M21:X IRONMONGERY

X115 IRONMONGERY: provide manufacturer's approved standard ironmongery and hardware, necessary to operate, tightly close, and securely lock operable casements. Do not use aluminium in frictional contact with other metals. Ironmongery sets including: hinges, bolts, and other items of attached hardware for all types of windows and unit assemblies, unless otherwise specified or approved, are to be:

Stainless Steel

supplied and installed complete with all associated and relevant components, mountings, fixings and accessories necessary to fulfil the intended function, particular purpose, operation and finished appearance.

X150 CATALOGUE REFERENCES: ironmongery product and catalogue references when indicated on Drawings or referred to in the Specification are indicative only of the quality, style, size and shape required. All ironmongery samples when submitted are to be supplied complete with all associated and relevant components, mountings, fixings and accessories intended to be installed in the finished work.

X160 FINISHES: unless otherwise indicated or approved, all ironmongery and hardware items exposed in the finished work are to have matching finish.

M21:Y COMPOUNDS AND SEALANTS

Y610 BEDDING COMPOUND: butyl based compound.

Y710 JOINT BACKING STRIP: type as recommended for particular purpose by joint sealant manufacturer.

Y720 SEALANTS FOR POINTING: one-part moisture cured silicone sealant to ASTM C 920 or BS EN ISO 11600, Type A as recommended by manufacturer:

Man: Dow Corning [ http://www.dowcorning.com/]
Ref: 795

MAN: TREMCO [http://www.tremcosealants.com/ ]

or other equal and approved.

WORKMANSHIP

M21:1 GENERALLY

1051 WORKMANSHIP GENERALLY including fabricating, welding, brazing, machining assembling and fixing are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

1551 PROTECTION OF COMPONENTS: do not deliver to site components which cannot be put immediately into suitable clean, dry, floored and covered storage. Stack near vertical on level bearers, separated with spacers to prevent damage by and to attached ironmongery and other component projections.

1601 MOISTURE CONTENT OF TIMBER COMPONENTS: during delivery, storage, fixing and thereafter to substantial completion, maintain conditions of temperature and humidity to suit specified moisture content(s) of components. When instructed by Engineer, test components with an approved electrical moisture meter used in accordance with manufacturer's recommendations.

M21:2 FIXING WINDOWS

2051 PRIMING AND SEALING: before fixing components ensure that surfaces of timber, which will be inaccessible after installation are primed or sealed as specified.

2101 CORROSION PROTECTION: before fixing, apply two coats of bitumen solution to BS 6949 or an approved mastic impregnated tape, to surfaces of components which will come into contact with other surfaces.

2251 WINDOW INSTALLATION: install windows and screens

into prepared openings, maintaining a uniform gap between the frame edge and the surrounding construction

without twist or diagonal racking.

2301 OPENINGS: ensure that damp proof courses are positioned correctly in relation to frames and are not displaced during fixing operations.

2451 FIXING OF ALUMINIUM FRAMES: when not predrilled or otherwise specified, position fixings not more than 250 mm from each end of jamb, adjacent to each hanging point of opening lights, and at maximum 600 mm centres.

2601 BACKFILLING OF STEEL FRAME SECTIONS: after fixing, fill the back of steel frame sections with a waterproof cement fillet.

2701 SEALING JOINTS:

preparation, depth and application are to be strictly in accordance with joint sealant manufacturer's recommendations

joint is to be thoroughly clean, dry and free from oil; finely abrade and prime as appropriate

mask adjacent surfaces which would be difficult to clean if smeared with sealant apply sealant ensuring maximum adhesion to sides of joint and with a neat, smooth, clean finish.

2751 IRONMONGERY: assemble and fix carefully and accurately using fastenings with matching finish supplied by ironmongery manufacturer. Prevent damage to ironmongery and adjacent surfaces. At completion check, adjust and lubricate as necessary to ensure correct functioning.

# M22 DOORS AND HATCHES

## GENERAL

### M22:A SCOPE

A105 SCOPE: this Section is for the specification of metal and wood doors, and access hatches and the like, together with related frames, linings and screens and associated hardware, fixings, ironmongery, accessories and sealant, including:

Aluminium Doors:
- sliding glazed doors
- pivoted and hinged doors

Steel Doors:
- flush and louvered doors
- fire resisting flush and sliding doors
- access hatches and panels
- steel door frames

Wood Doors:
- semi-solid and solid core flush doors
- panelled doors
- wood door frames and linings

### M22:C DEFINITIONS

C105 FIRE RESISTING DOOR: a door which has been constructed in such a manner that when installed in an assembly and tested, it will pass with BS 476-22 and BS EN 1634-1, and can be rated as resisting fire for the specified duration when tested to BS EN 1643-1. A fire resisting door assembly must have been tested and carry the identifying label of an approved independent testing and inspection system / agency or laboratory, confirming its fire resistance rating.

C120 DIRECTION OF OPENING: on Architectural Drawings, the indications for direction of opening are as follows:

- sliding doors are indicated by an arrow indicating the direction of slide

hinged doors are indicated by a dotted triangle, the vertex of which indicates the hinge or pivot side

pull and slide doors are indicated by a vertical line followed by a horizontal arrow indicating the direction of slide

M22:D SUBMITTALS

D105 SHOP DRAWINGS: submit shop drawings showing fabrication and installation of each type of door and frame specified, include information not fully detailed in manufacturer's standard data, and the following:

fabrication, layout, and installation details, including anchors and conditions at openings

details of each frame type and elevations of door design type

full-size details of typical composite members, including reinforcement and extent of blocking and holes for ironmongery and hardware

fire ratings for fire-resisting doors and assemblies

ironmongery and hardware, including operators

glass and glazing details

louvres and accessories.

D110 DOOR SCHEDULE: submit schedule of doors and frames using same reference numbers for details and openings as those on Drawings.

indicate ironmongery and hardware set requirements

indicate coordination of glazing frames and stops with glass and glazing requirements.

D115 INSTALLER CERTIFICATES: signed by product manufacturer certifying that the Installer is approved, authorized, or licensed by manufacturer to install his products.

D120 INSTALLER EXPERIENCE: provide a list of five (5) projects (minimum) of a similar nature carried out successfully by the Installer with the same product endorsed by the manufacturer's representative.

D125 TEST CERTIFICATE: provide a certificate of test from an approved independent testing laboratory describing the fire test and confirming the fire rating of the fire door system and its components.

D205 CATALOGUES: submit manufacturer's catalogues and technical specifications for materials and products proposed to be incorporated into the works.

D215 MANUFACTURER'S DATA: submit manufacturer's product data for each type of door and frame specified, including but not necessarily limited to the following:

construction details and fabrication methods

profiles and dimensions of individual components

data on hardware, accessories, trim, louvers and factory finishes

identifying fire-resistance label and sound rating compliances

installation instructions

recommendations for maintaining and cleaning exposed surfaces.

D250 GUARANTEE: provide two copies of a written guarantee in a form acceptable to the Engineer, signed by the manufacturer and the Contractor, undertaking to:

replace doors which fail in materials or workmanship within five (5) years of the date of Substantial Completion. Failure of materials and workmanship shall include, but not be limited to: excessive air infiltration, water penetration or condensation, excessive deflections or deterioration in metal, other than due to normal weathering and any defects in anchorage, sealants, fixings, accessories and other components of the work

repair or replace finishes or coatings which fail or become defective and defined to include abnormal deterioration, ageing or weathering:

Warranty Period: 15 years from date of Substantial Completion for electrostatically applied polyester powder coating.

M22:E <u>SAMPLES</u>

E105 SAMPLES: within the programmed time submit samples of the specified products, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

E106 MOCK-UPS: within the programmed time assemble a mock-up sample of the items specified. Approved samples may be included in the finished work. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

M22:F PERFORMANCE REQUIREMENTS

F105 FIRE RESISTING DOORS AND ASSEMBLIES: all fire resisting doors, hatches, and the like, together with associated component assemblies shall have been tested and must carry the identifying label of an approved independent testing and inspection system / agency or laboratory, confirming their fire resistance rating. The door test should cover all configurations available for the door being tested. In addition, fire doors are to be designed and manufactured in accordance with ISO 9002. Door components shall be factory fitted to the door leaves.

F110 FIRE RESISTING DOORS ASSEMBLIES: all fire resisting doors assemblies, together with all associated assembly components, including but not necessarily limited to door frames and door hardware shall either be the product of the door manufacturer or otherwise approved by him, and presented under Submittals requirements as a single product package.

F115 FIRE RESISTING DOOR COMPONENTS: all components of fire resisting doors and assemblies, including but not limited to: door leaves, frames, ironmongery, hardware and glazing, shall carry identifying labels of an approved independent testing and inspection system/ agency or laboratory confirming their individual fire resistance rating. The door test should cover all configurations available for the door being tested. The rating of all door components shall be equal to the rating of the door assembly, and to the same standard. Locks/ latches, overhead closers, hinges and all hardware must be as tested or labelled components of equal specification that can demonstrate contribution to the required integrity.

F120 FIRE LABELS: all fire labels shall be issued by the testing laboratory. Alternatively, labels may be produced by the door assembly manufacturer provided:

the manufacturer has a quality assurance system to ISO 9002 or approved equal

the label produced shall bear a serial number, the name of the testing laboratory and the date and number of the licence

the testing laboratory or a certified quality control system shall certify the consistency of the door assembly production as per the tested specimen

the testing laboratory authorises the manufacturer to produce the labels on the conditions listed above.

F125 FIRE LABELS: labels shall be produced by an approved independent testing laboratory, such as UL, that have a continuous inspection program to ensure conformity of production of fire doors to the tested sample. In case the certifying laboratory does not have this continuous inspection program, then the fire door shall bear, in addition to the label, the quality mark of an approved independent inspection agency, such as BSI or ISO, to certify the consistency of production.

F135 MANUFACTURER QUALIFICATIONS: a firm experienced in manufacturing items specified in this section similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to manufacture required units.

F140 INSTALLER QUALIFICATIONS: a qualified firm specializing in performing the work of this Section with minimum three years documented experience and that is approved, authorized, or licensed by the product manufacturer to install his product and that is eligible to receive manufacturer's warranty. Include project names and addresses of Engineers and Owners, and other relevant information

F150 FIRE RESISTING DOOR CLOSERS: all fire resisting doors shall be fitted with door closers that automatically close and positively latch the door. Door closers shall be supplied with non-combustible fluid.

F160 FIRE RESISTING DOOR ENCLOSURES: the wall or panel in which the fire door is installed shall have a fire rating equal to or exceeding that of the door. Furthermore, the space between the top of the fire resisting door assembly and the structural soffit above shall be closed by a wall or an appropriate panel with a fire rating equal to or exceeding that of the door.

F180 SOUNDPROOF DOORS: all soundproof doors, together with associated component assemblies shall have been tested and must carry the identifying label of an approved independent testing and inspection agency or laboratory, confirming their sound rating.

F185 WEATHER STRIPPING: provide weather seals to all external doors to prevent air-infiltration and water penetration.

F190 Available Manufacturers: manufacturers’ names and products listed hereinafter are indicative only and are to comply with requirements stated in this specification.

MATERIALS AND PRODUCTS

M22:G COMPONENTS

G105 METAL AND WOOD COMPONENTS of composite units, including fastenings, fixings, treatments, finishings, coatings and jointing materials are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

G110 Aluminium Extrusions: alloy and temper recommended by aluminium door manufacturer for strength, corrosion resistance, and application of required finish, but not less than 150-MPa ultimate tensile strength, not less than 110-MPa minimum yield strength, and not less than 1.6-mm thickness at any location for the main frame and sash members.

Sheet and Plate: BS EN 485- 1 to 4 and BS EN 515.

Extruded Bars, Rods, Profiles, and Tubes: see clause M:11-H280.

Extruded Structural Pipe and Tubes: BS 1161.

G115 FASTENERS: fasteners for aluminium members shall be from aluminium, nonmagnetic stainless steel, epoxy adhesive, or other materials warranted by manufacturer to be noncorrosive and compatible with aluminum window members, trim, hardware, anchors, and other components. Cadmium-plated steel fasteners are not permitted.

M22:J METAL DOORS, DOOR FRAMES AND THE LIKE

J105 DELIVER doors and frames cardboard-wrapped or crated to provide protection during transit and job storage. Provide additional protection to prevent damage to finish of factory-finished doors and frames.

J115 FACTORY-FINISHED doors or frames shall be delivered with heavy duty protective film that shall remain during the construction period.

J210 PIVOTED AND HINGED ALUMINIUM DOORS: similar to the requirements of section M11 manufactured from extruded aluminium sections to BS EN 515, BS EN 573-3, BS EN 755-1>9, BS EN 12020-1>2, temper designation 6063 TF with polyester powder coating finish, neoprene glazing gaskets double or single action hydraulic floor springs, weather strips and all necessary hardware and ironmongery.

BS EN 12373-1BS 3987

J305 FLUSH STEEL DOORS: 45 mm thick steel hollow doors to BS 6510 made of pregalvanised sheet steel to BS EN 10143 and cold rolled mild steel sections to BS EN 10162, hot dip galvanised to BS EN ISO 1461 with coating thickness 180 g/m2. Doors are to be flush, watertight, with closed tops and edges and reinforced internally with vertical stiffeners welded and spaced not more than 150 mm over centres.

Door cores are to be constructed with:

> polyurethane rigid foam insulation with compressive strength minimum 0.14 N/mm2. The polyurethane shall be foamed in place or laminated to each face sheet. Voids in foam shall not exceed 13 mm in any direction.
> the strength of the bond between the insulation and the steel face sheets shall exceed the strength of the insulation, so that delamination does not occur.

Reinforce doors and frames to receive surface-applied ironmongery and hardware.
Drilling and tapping for surface applied ironmongery may be done at project site.

Doors are to be supplied complete with all necessary accessories and hardware, vision panels and louvres ,as shown on the Drawings.

Man: Ceco Door Products [http://www.cecodoor.com/]
Man: Curries Co. [http://www.curries.com/]
Man: Overly Door Co. [http://www.overly.com/]
Man: IR Martin Roberts. [http://www.irmartinroberts.co.uk/]
Man: Al Kuhaimi Metal Industries. [http://www.alkuhaimi.com/]

or other equal and approved.

J310 LOUVRED STEEL DOORS: 45 mm thick steel hollow doors to BS 6510 or ANSI A250.8 to the thickness indicated on drawings, made of pre-galvanised sheet steel to BS EN 10143 and cold rolled mild steel sections to BS EN 10162, hot dip galvanised to BS EN ISO 1461. Door cores are to be constructed with polyurethane rigid foam insulation . Doors are to be fitted with 3 mm thick louvres, as shown on the Drawings. Doors are to be supplied complete with all necessary accessories and hardware.

Provide louvres according to SDI 111C for interior doors where indicated, with blades or baffles formed of 0.7 mm thick cold-rolled steel sheet set into minimum 1 mm-thick steel frame.

For fire-rated automatic louvers, provide louvers constructed with movable blades closed by actuating fusible links at 65 deg. C and labelled and listed for use in fire-rated door assemblies of type and fire resistance rating indicated by the same inspecting and testing agency who established fire resistance rating of door assembly.

Man: Ceco Door Products [http://www.cecodoor.com/]
Man: Curries Co. [http://www.curries.com/]
Man: Overly [http://www.overly.com/]
Man: IR Martin Roberts. [http://www.irmartinroberts.co.uk/]

Man: Al Kuhaimi Metal Industries. [http://www.alkuhaimi.com/]

or other equal and approved.

J320 FIRE RESISTING FLUSH STEEL DOORS: fire resisting doors with rating indicated on drawings satisfying the requirements of BS 476-20 and 22. Flush fitting steel door to the thickness, construction and infill of approved non-combustible thermal insulating material indicated on fire test report. Door assembly shall be provided complete with frame, fire resisting hardware, and all necessary accessories and fixings. Raised thresholds are not permitted.
Doors are to be self closing and are to be released automatically from hold-open position in case of fire by means of electromagnetic devices connected to fire alarm system.

Man: Ceco Door Products [http://www.cecodoor.com/]
Man: Curries Co. [http://www.curries.com/]
Man: Overly Door Co. [http://www.overly.com/]
Man: IR Martin Roberts. [http://www.irmartinroberts.co.uk/]
Man: Chubb Security Installations [http://www.csisec.com/]
Man: Al Kuhaimi Metal Industries. [http://www.alkuhaimi.com/]

or other equal and approved.

J510 STEEL ACCESS HATCHES: comprising solid steel plate covers and channel frames with zinc coated finish, supplied with neoprene gaskets, hinges, lifting mechanism, automatic hold-open and operating arm, spring latch, inside and outside handles, hasp, staple and heavy duty padlock.

Complete access hatches assembly is to carry the identifying label of the testing agency system or laboratory confirming its' fire rating. Access hatches are to be self closing by means of springs that can be detached during maintenance.

J515 FIRE RESISTING STEEL ACCESS PANEL: constructed from galvanised steel sheets to BS EN 10143. Panel frame and door to be to the thickness and construction indicated on fire test certificate. Hinges are to be concealed pin type. Panel is to be 120 minutes fire resisting. Locks shall be cylinder operated**.**

Man: Nystrom http://www.nystrom.com/
Ref: U-Series

or other equal and approved.

J910 STEEL DOOR FRAMES: to the general requirements of BS 1245 or ANSI A250.8, but to non-standard sizes and profiles, constructed from not less than 1.5 mm thick galvanised steel sheet, finished with factory applied corrosion inhibiting protective coating and supplied complete with transoms, rubber silencers and glazing beads, as shown on the Drawings.

J915 FINISHES TO STEEL DOORS AND FRAMES: steel doors and frames shall have the following finishes:

steel doors shall have factory-applied paint finish system complying with ANSI A 250.3 for performance and acceptance criteria

factory-finished doors shall have heavy duty protective film that shall not be removed during the construction period

steel frames shall be factory-primed for spray-applied field painting.

M22:K WOOD DOORS, DOOR FRAMES AND THE LIKE

K110 SEMI-SOLID CORE FLUSH WOOD DOORS: to BS 4787-1, comprising preservative treated softwood framing and noggings faced both sides with 6 mm plywood glued and pressed to framing and lipped on all edges with hardwood. Plywood facing is to be finished to receive paint or covered with hardwood or decorative veneer, as shown on the Drawings.

Faces:

Opaque Finish: any closed-grain hardwood plywood

Edges: hardwood edges for painting.

Grade: premium

Core: ladder core

Rails and Stiles: provide wood rails and stiles same thickness as core:

125 mm top rail
100 mm jamb stiles
250 mm bottom rail
63 mm midrail

Blocking: provide wood blocking of same thickness as core where necessary as follows:

at hinges.
at locks
at door closers

Man: Leaderflush + Shapland & Petter [http://www.lsleaderflushshapland.co.uk/]
Man: Bridgman IBC [http://www.bridgman-ibc.com/].
Man: Graefe Ltd. [www.graefe.co.uk]
Man: Noberne Doors Ltd. [http://www.noberne-fire-doors-and-seals.co.uk/]
Man: Graham Doors [http://www.grahamdoors.com/]

or other equal and approved.

K120 SOLID CORE FLUSH WOOD DOORS: to BS 4787-1 or WWDA I.S. 1.2, comprising preservative treated softwood solid core faced both sides with 6 mm plywood glued and pressed to core and lipped on all edges with hardwood. Plywood facing is to be finished to receive paint or covered with hardwood or decorative veneer, as shown on the Drawings.

Faces:

Opaque Finish: any closed-grain hardwood plywood

Stiles and Rails: softwood rails and stiles with hardwood edges for painting.

Blocking: provide wood blocking of same thickness as core where necessary as follows:

at hinges
at locks
at door closers

Grade: custom

Construction: 7 plies (glued block core)

Core: glued-block core
Bonding: stiles and rails bonded to core, then entire unit abrasive planed before veneering.

Man: Leaderflush + Shapland & Petter [http://www.lsleaderflushshapland.co.uk/]
Man: Bridgman IBC. [http://www.bridgman-ibc.com/]
Man: Graefe. [www.graefe.co.uk]
Man: Noberne Doors Ltd. [http://www.noberne-fire-doors-and-seals.co.uk/]
Man: Graham Doors. [http://www.grahamdoors.com/]

or other equal and approved.

K910 WOOD DOOR FRAMES AND LININGS: to the general requirements of BS 1567 and BS 4787-1, but of non-standard dimensions, comprising preservative treated hardwood members finished to receive paint or clear finish, as shown on the Drawings.

K920 FINISHES TO WOOD DOORS AND FRAMES: wood doors and frames shall have the following finishes:

wood doors and frames for opaque finishes shall have field-applied paint finish system

factory-finished doors and frames shall have heavy duty protective film that shall not be removed during the construction period.

M22:Y COMPOUNDS AND SEALANTS

Y610 BEDDING COMPOUND: butyl based compound.

Y710 JOINT BACKING STRIP: type as recommended for particular purpose by joint sealant manufacturer.

Y720 SEALANTS FOR POINTING: one-part moisture cured silicone sealant to BS EN ISO 11600, as recommended by manufacturer:

Man: Dow Corning
Ref: 795

Man: Fosroc
Ref: Nitoseal 125

or other equal and approved.

WORKMANSHIP

M22:1 GENERALLY

1051 WORKMANSHIP GENERALLY including fabricating, welding, brazing, machining assembling and fixing are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

1055 STANDARD: work in this Section is to be executed generally in accordance with BS 8000-5.

1101 FIRE RESISTANCE: the specified performance is to be the minimum period attained when tested for integrity in accordance with BS 476-20 and 22.

1551 PROTECTION OF COMPONENTS: do not deliver to site components which cannot be put immediately into suitable clean, dry, floored and covered storage. Stack near vertical on level bearers, separated with spacers to prevent damage by and to attached ironmongery and other component projections.

1601 MOISTURE CONTENT OF TIMBER COMPONENTS: during delivery, storage, fixing and thereafter to substantial completion maintain conditions of temperature and humidity to suit specified moisture content(s) of components. When instructed by Engineer, test components with an approved electrical moisture meter used in accordance with manufacturer's recommendations.

M22:2 FIXING DOORS

2051 PRIMING AND SEALING: before fixing components ensure that surfaces of timber which will be inaccessible after installation are primed or sealed as specified.

2101 CORROSION PROTECTION: before fixing, apply two coats of bitumen solution to BS 6949 or an approved mastic impregnated tape, to surfaces of components which will come into contact with other surfaces.

2151 BUILDING IN will not be permitted except where specifically stated on the Drawings.

2152 BUILDING IN: components which are being built in must be braced and protected as necessary to prevent distortion and damage during erection of adjacent structure.

2251 DOOR INSTALLATION: install doors, shutters, grilles, screens and the like:

into prepared openings, maintaining a uniform gap between the frame edge and the surrounding construction

without twist or diagonal racking.

2255 FIRE DOOR INSTALLATION: install fire doors to comply with manufacturer's written instructions, referenced quality standard, and as indicated.

install fire-rated doors in corresponding fire-rated frames according to relevant codes and standards

install fire-rated frames according to NFPA 80

fire doors shall be installed only by experienced installers. Submit for prior approval by the Engineer the names of proposed installers referenced to works of a similar nature carried out satisfactorily by the installer on other projects using the specified product, together with relevant dates and any other information required by the Engineer.

2301 OPENINGS: ensure that damp proof courses are positioned correctly in relation to frames and are not displaced during fixing operations.

2351 FIXING OF TIMBER FRAMES: when not predrilled or otherwise specified, position fixings not more than 150 mm from each end of jamb, adjacent to each hanging point of opening lights, and at maximum 600 mm centres.

2401 FIXING OF STEEL FRAMES: when not predrilled or otherwise specified, position fixings not less than 50 mm and not more than 190 mm from each end of jamb, adjacent to each hanging point of opening lights, and at maximum 900 mm centres.

2451 FIXING OF ALUMINIUM FRAMES: when not predrilled or otherwise specified, position fixings not more than 250 mm from each end of jamb, adjacent to each hanging point of opening lights, and at maximum 600 mm centres.

2701 SEALING JOINTS:

preparation, depth and application are to be strictly in accordance with joint sealant manufacturer's recommendations

joint is to be thoroughly clean, dry and free from oil; finely abrade and prime as appropriate

mask adjacent surfaces which would be difficult to clean if smeared with sealant apply sealant ensuring maximum adhesion to sides of joint and with a neat, smooth, clean finish.

# M23 SHUTTERS, GRILLES AND OPERABLE PARTITIONS

## GENERAL

### M23:A SCOPE

A105 SCOPE: this Section is for the specification of metal and wood shutters and grilles, including sliding folding partitions, and the like, together with related hardware, fixings, ironmongery, accessories and sealant, including:

Shutters, Grilles and the like:

steel rolling shutters

### M23:C DEFINITIONS:

C105 FIRE RESISTING SHUTTER: a shutter, which has been constructed in such a manner that when installed in an assembly and tested, it will pass with BS 476-22 or NFPA 80, and can be rated as resisting fire for the specified duration. A fire resisting shutter must have been tested and carry the identifying label of an approved independent testing and inspection assembly or laboratory, confirming its fire resistance rating.

C115 SMOKE SHUTTER: a fire resisting shutter which, in addition to having intumescent seals to seal hot smoke, also has approved quality draught seals to seal cold smoke, installed in accordance with NFPA 105-93: Installation of Smoke-Control shutter Assemblies. A smoke shutter must have been tested and carry the identifying label of an approved independent testing and inspection assembly or laboratory, confirming its rating.

### M23:D SUBMITTALS

D105 SHOP DRAWINGS: submit shop drawings showing fabrication and installation of each type of shutter, grille and partition specified, include information not fully detailed in manufacturer's standard data, and the following:

fabrication, layout, and installation details, including anchors and conditions at openings

details of each frame type and elevations of door design type

full-size details of typical composite members, including reinforcement and extent of blocking and holes for ironmongery and hardware

fire ratings for fire-resisting component and assemblies

ironmongery and hardware, including operators

glass and glazing details

louvres and accessories.

D110 SCHEDULE: submit schedule of shutters, grilles and partitions using same reference numbers for details and openings as those on Drawings.

indicate ironmongery and hardware set requirements

indicate coordination of glazing frames and stops with glass and glazing requirements.

D205 CATALOGUES: submit manufacturer's catalogues and technical specifications for materials and products proposed to be incorporated into the works.

D215 MANUFACTURER'S DATA: submit manufacturer's product data for each type of shutter, grille and partition specified, including but not necessarily limited to the following:

construction details and fabrication methods

profiles and dimensions of individual components

data on hardware, accessories, trim, louvres and factory finishes

identifying fire-resistance label and sound rating compliances

installation instructions

recommendations for maintaining and cleaning exposed surfaces.

M23:E SAMPLES:

E105 SAMPLES: within the programmed time submit samples of the specified products, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

E106 MOCK-UPS: within the programmed time assemble a mock-up sample of the specified. Approved samples may be included in the finished work. Obtain approval of

appearance and other relevant characteristics before proceeding with manufacture or delivery.

## M23:F PERFORMANCE REQUIREMENTS

F105 FIRE RESISTING SHUTTERS, GRILLES, OPERABLE PARTITIONS AND ASSEMBLIES: all fire resisting shutters, grilles, operable partitions and the like, together with associated component assemblies shall have been tested and must carry the identifying label of an approved independent testing and inspection agency or laboratory, confirming their fire resistance rating. The door test should cover all configurations available for the door being tested. In addition, fire shutters, grilles, and operable partitions are to be designed and manufactured in a system conforming to ISO 9001.

F110 FIRE RESISTING SHUTTERS, GRILLES AND OPERABLE PARTITIONS COMPONENTS: all components of fire resisting shutters and assemblies, including but not limited to: shutter curtains, frames, hardware, and glazing, shall carry identifying labels of an approved independent testing and inspection assembly or laboratory, confirming their individual fire resistance rating. The rating of all shutter components shall be equal to the rating of the door assembly and to the same standard. Locks/ latches, overhead closers, hinges and all hardware must be as tested or labelled components of equal specification that can demonstrate contribution to the required integrity.

F115 FIRE LABELS: all fire labels shall be issued by the testing laboratory. Alternatively, labels may be produced by the door assembly manufacturer provided:

the manufacturer has a quality assurance system to ISO 9001 or approved equal

the label produced shall bear a serial number, the name of the testing laboratory and the date and number of the licence

the testing laboratory or a certified quality control assembly shall certify the consistency of the door assembly production as per the tested specimen

the testing laboratory authorises the manufacturer to produce the labels on the conditions listed above.

F122 FIRE LABELS: labels shall be produced by an approved independent testing laboratory, such as UL, that have a continuous inspection program to ensure conformity of production of fire shutters, grilles, and operable partitions to the tested sample. If the certifying laboratory does not have this continuous inspection program the fire door shall bear, in addition to the label, the quality mark of an approved independent inspection agency, such as BSI or ISO, to certify the consistency of production.

F405 WEATHER STRIPPING: provide weather seals to all external shutters and grilles.

## MATERIALS AND PRODUCTS

### M23:G COMPONENTS

G105 METAL AND WOOD COMPONENTS of composite units, including fastenings, fixings, treatments, finishings, coatings and jointing materials are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

### M23:L METAL SHUTTERS, GRILLES AND THE LIKE

L220 STEEL ROLLING SHUTTER: made of interlocking slats cold rolled from structural-quality, cold-rolled steel sheets galvanised to BS EN ISO 1461 and BS EN 10143. Slats are to be designed to withstand wind loading indicated, in a continuous length for width of door without splices. Alternate slats are to be fitted with malleable iron end locks. Minimum slat thickness is to be 0.8 mm for shutters up to 4000 mm wide, 1 mm for shutters 4000 - 6000 mm wide and 1.3 mm for shutters over 6000 mm wide. Bottom of curtain to have two reinforcing galvanised steel angles with neoprene astragal. Spring counterbalance is to be housed in a galvanised steel pipe of diameter and wall thickness to restrict maximum deflection to 2.5 mm per meter of door width. Springs to be helical torsion type designed to include an overload factor 25% and for optimum ease of operation. Springs are to be grease packed and are to be mounted on a cold rolled galvanised steel inner shaft.

Furnish sealed ball bearings to minimise wear of pipe shaft rotation around inner shaft. Spring tension is to be adjustable from outside of end bracket plate.

Shutter is to be one-hour fire resistant.

Operation: motorized

Operator: provide electric door operator assembly complying with NFPA 70. It shall be of size and capacity recommended and provided by door manufacturer for door and operational life specified, with electric motor and factory-prewired motor controls, starter, gear-reduction unit, solenoid-operated brake, clutch, remote-control stations, control devices, integral gearing for locking door, and accessories required for proper operation.

Electric Motors: provide high-starting torque, reversible, continuous-duty, Class A insulated electric motors. It shall comply with NEMA MG 1, with overload protection, sized to start, accelerate, and operate door in either direction, from any position, at not less than 0.2 m/s or more than 0.3 m/s, without exceeding nameplate ratings or considering service factor.

Type: Polyphase, medium-induction type.

Service Factor: According to NEMA MG 1, unless otherwise indicated.

Coordinate wiring requirements and electric characteristics of motors with building electrical system.

Automatic Closing: provide automatic-closing device inoperative during normal door operations. Automatic closing shall have a rate of descent controlled by a governor. Governor unit shall comply with requirements of NFPA 80, easily tested and reset release mechanism, and designed to be activated by fire alarm and detection system .

Provide door with all necessary hardware, ventilation slots and other accessories indicated on Drawings.

Man: Clopay Building Products Co. (http://www.clopay.com/)
Man: Bolton Gate Co Ltd. (http://www.boltongate.co.uk/)
Man: Kaba Henderson Bostwick. (http://www.kabadoorsystems.co.uk/)
Man: Overhead Door Corporation. (http://www.overheaddoor.com/)
Man: Al Kuhaimi Metal Industries. (http://www.alkuhaimi.com/)

or other equal and approved.

## M23:Y COMPOUNDS AND SEALANTS

Y610 BEDDING COMPOUND: butyl based compound.

Y710 JOINT BACKING STRIP: type as recommended for particular purpose by joint sealant manufacturer.

Y720 SEALANTS FOR POINTING: one-part moisture cured silicone sealant to ASTM C 920 or BS EN ISO 11600, Type A as recommended by manufacturer:

Man: Dow Corning (http://www.dowcorning.com/)
Ref: 795

Man: Tremco

or other equal and approved.

## WORKMANSHIP

### M23:1 GENERALLY

1051 WORKMANSHIP GENERALLY including fabricating, welding, brazing, machining assembling and fixing are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

1101 FIRE RESISTANCE: the specified performance is to be the minimum period attained when tested for integrity in accordance with BS 476-20 and 22.

1551 PROTECTION OF COMPONENTS: do not deliver components to site, which cannot be put immediately into suitable clean, dry, floored and covered storage. Stack near vertical on level bearers, separated with spacers to prevent damage by and to attached ironmongery and other component projections.

1601 MOISTURE CONTENT OF TIMBER COMPONENTS: during delivery, storage, fixing and thereafter, to Substantial Completion, maintain conditions of temperature and humidity to suit specified moisture content(s) of components. When instructed by the Engineer, test components with an approved electrical moisture meter used in accordance with manufacturer's recommendations.

### M23:2 FIXING SHUTTERS

2051 PRIMING AND SEALING: before fixing components ensure that surfaces of timber, which will be inaccessible after installation, are primed or sealed as specified.

2101 CORROSION PROTECTION: before fixing, apply two coats of bitumen solution to BS 6949 or an approved mastic impregnated tape, to surfaces of components which will come into contact with other surfaces.

2152 BUILDING IN: components which are being built in must be braced and protected as necessary to prevent distortion and damage during erection of adjacent structure.

2251 INSTALLATION: install shutters, grilles and the like:

into prepared openings, maintaining a uniform gap between the frame edge and the surrounding construction

without twist or diagonal racking.

2701 SEALING JOINTS:

preparation, depth and application are to be strictly in accordance with joint sealant manufacturer's recommendations

joint is to be thoroughly clean, dry and free from oil; finely abrade and prime as appropriate

mask adjacent surfaces which would be difficult to clean if smeared with sealant and apply sealant ensuring maximum adhesion to sides of joint and with a neat, smooth, clean finish.

# M25 DOOR HARDWARE

## GENERAL

### M25:A SCOPE

A105 SCOPE: this Section is for the specification of door hardware, including ironmongery, fixings and related accessories.

### M25:C SUBMITTALS

C105 SHOP DRAWINGS: submit shop drawings showing the installation of each type of door hardware specified, include information not fully detailed in manufacturer's standard data, and the following:

fabrication, layout, and installation details.

fire ratings for fire-resisting hardware.

detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

C110 HARDWARE SCHEDULE: submit hardware schedule using same reference numbers for details and openings as those indicated on Drawings.

C205 CATALOGUES: submit manufacturer's catalogues and technical specifications for materials and products proposed to be incorporated into the works.

C215 MANUFACTURER'S DATA: submit manufacturer's product data for each type of door hardware specified, including but not necessarily limited to the following:

data on hardware, accessories, trim, louvres and factory finishes

testing certificates from an approved independent testing laboratory indicating compliance with specified European standards and performance requirements showing:

category of use
durability/ test cycles
test door mass
fire behavior
safety in use
corrosion resistance
identifying fire-resistance label.
installation instructions

recommendations for maintaining and cleaning exposed surfaces.

Testing certificates not to European Standards shall be accompanied by a comparison by a qualified testing agency showing that the results of the submitted tests are equal or better than the specified tests.

C220 SAMPLES: within the programmed time submit samples of the hardware products specified in this Section, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

C225 GUARANTEE: Provide complete guarantee in which Manufacturer, Contractor and Installer are jointly and severally responsible and agree to repair or replace without limitations, all or any part of the items, which fails in performance, operation or finish. Failures include, but are not limited to, the following:

structural failures including excessive deflection, cracking, or breakage

faulty operation of operators and door hardware

deterioration of metals, metal finishes, and other materials beyond normal weathering.

Warranty Period:

three years from date of Substantial Completion, unless otherwise indicated
five years from date of Substantial Completion for Electromagnetic Locks
ten years from date of Substantial Completion for Manual Closers
five years from date of Substantial Completion for Concealed Floor Closers.

This guarantee shall not deprive the Employer of other rights the Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under other requirements of the Contract Documents.

M25:D PERFORMANCE REQUIREMENTS

D105 LABELS: all hardware components of fire resisting doors assemblies including, but not limited to hinges, locks, bolts and door closers, shall carry the identifying labels of an approved independent testing and inspection agency or laboratory, confirming their fire resistance rating. The rating of all door components shall be equal to the rating of the door assembly.

D115 DOOR CLOSERS: all fire resisting doors assemblies shall be fitted with door closers to close and positively latch the door.

D120 Manufacturer Qualifications: Hardware products shall be fabricated only in U.S.A or West Europe by an approved manufacturer who is specialized in hardware production

similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance not less than ten years and manufactured in a system conforming to ISO 9001. US or West European firms fabricating in other countries shall present sufficient evidence acceptable to the Engineer that their factories operating under license are under ISO 9001 and under their strict supervision and that the products are identical in all respects to European or US products and conform to the specified standards.

D125 Installer Qualifications: An experienced installer who has completed door hardware similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance not less than five years. Installer shall be approved and licensed by the hardware manufacturer.

D130 Supplier Qualifications: Door hardware supplier with warehousing facilities in Project's vicinity and who is or employs a qualified Architectural Hardware Consultant, available during the course of the Work to consult with Contractor, Engineer, and Employer about door hardware and keying.

D135 Source Limitations: Obtain each type and variety of door hardware from a single manufacturer, unless otherwise indicated.

Notwithstanding manufacturers names and products listed in this section, hardware items supplied and installed shall be similar in quality, performance and lifetime.

D140 The publications listed below form a part of this Specification to the extent referenced. The publications are referred to in the text by the basic designation only.

NFPA 80-99: Fire Doors and Fire Windows

BS 8214 Code of Practice for fire door assemblies with non-metallic leaves

BS EN 1634-1: Fire resistance tests for door and shutter assemblies. Fire doors and shutters.

BS EN 1634-3: Fire resistance tests for door and shutter assemblies.NFPA 101-2000: Code for Safety to Life from Fire in Buildings and Structures.

D145 HARDWARE SCHEDULE: The manufacturer's names and references included in the schedule are only included to establish the minimum standards required and to establish guidelines as to shape, function, material and finish of the hardware items required. Hardware items, which are similar to those setout in the schedule and in accordance with minimum standards set out this specification, can be selected from any of the approved manufacturers listed.

M25:E MAINTENANCE SERVICE

E150 Maintenance Tools and Instructions: Furnish a complete set of specialized tools and maintenance instructions as needed for Employer's continued adjustment, maintenance, and removal and replacement of door hardware.

E155 Maintenance Service: Beginning at Substantial Completion, provide six (6) months' full maintenance by skilled employees of door hardware Installer. Include quarterly preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper door hardware operation. Provide parts and supplies same as those used in the manufacture and installation of original products

## MATERIALS AND PRODUCTS

### M25:G COMPONENTS

G105 METAL COMPONENTS of composite units, including fastenings, fixings, treatments, finishings, coatings and jointing materials are to be in accordance with the requirements of Section M11 of the Specification.

### M25:H MANUFACTURERS

H105 Hinges:
- Man: Assa Abloy.
- Man: Ingersoll-Rand Company.
- Man: D Line [http://www.dline.com/].

H110 Pivots and Pivot Hinges:
- Man: D Line [http://www.dline.com/].
- Man: Geze [http://www.geze.com/?L=1]
- Man: Dorma http://www.dorma.com/en/

H115 Mechanical Locks and Latches:
- Man: Legge, an Ingersoll-Rand Company.
- Man: Dorma [http://www.dorma.com/en/].
- Man: Nemef

H120 Electromagnetic Locks and Latches:
- Man: Allgood Modric [http://www.allgoodww.com/].
- Man: Securitron (Assa Abloy) [http://www.securitron.com/].
- Man: Locknetics, an Ingersoll-Rand Company.

H125 Lever Handels:
- Man: Allgood Modric [http://www.allgoodww.com/].
- Man: D Line [http://www.dline.com/]

Man: Ingersol Rand

H130 Flush Bolts:
Man: Assa Abloy.
Man: Allgood Modric [http://www.allgoodww.com/].
Man: Ingersoll-Rand Company.

H135 Exit Devices

Man: Allgood Modric [http://www.allgoodww.com/].
Man: Dorma [http://www.dorma.com/en/].
Man: JPM, an Assa Abloy Company.

H140 Cylinders:

Man: Ingersoll-Rand Company.
Man: Union an Assa Abloy Company
Man: Allgood Modric

H145 Key Control Systems:
Man: Key Control Systems, Inc. (KCS).
Man: Sargent Manufacturing Company; Div. of ESSEX Industries, Inc. (SGT).
Man: Ingersoll-Rand Company

H150 Coordinators:
Man: Rixson-Firemark, Inc.; Div. of Yale Security Inc. (RIX).
Man: NT Monarch Hardware; an Ingersoll-Rand Company (NTM).
Man: Ingersoll-Rand Company.

H160 Closers
Man: Allgood Modric
Man: DORMA Door Controls Inc.; Member of The DORMA Group (DC).
Man: Geze [http://www.geze.com/?L=1]

H165 Concealed Closers:
Man: Briton; an Ingersoll-Rand Company
Man: DORMA Door Controls Inc.; Member of The DORMA Group (DC).
Man: Geze [http://www.geze.com/?L=1]
H170 Electromechanical Closers:
Man: Allgood Modric
Man: Geze [http://www.geze.com/?L=1]
Man: DORMA Door Controls Inc.; Member of The DORMA Group (DC).

Man: Briton; an Ingersoll-Rand Company.

H175 Stops And Holders
Allgood Modric
Dorma Door Controls Inc.; Member of The Dorma Group (DC).
LCN Closers; an Ingersoll-Rand Company (LCN).

H180 Door Gasketing:
Man: Hager Companies (HAG).
Man: Pemko.
Man: Ferco.

or other equal and approved.

M25: X DOOR HARDWARE AND MECHANICAL LOCKS

X105 GENERAL: unless otherwise stated, all hardware shall be supplied by a single manufacturer/supplier only:

the hardware supplier shall offer full technical support and shall have suitably qualified staff capable of preparing and amending proper door hardware schedules and advise on all technical issues, including master key and keying systems and other matters concerning specification, installation and operation of door hardware

unless otherwise stated, hardware to aluminium door units shall be by the aluminium fabricator in accordance with this specification but with finishes to match aluminium sections

hardware shall be supplied complete with all matching fixings

referenced standards set minimum requirements. If this specification requires higher standards, the more stringent requirement will apply as in the case of certain components where U.L. certification is required.

the Contractor shall:

provide approved weatherproof storage facilities for all hardware delivered to the site

check the hardware on installation for correct operation, maintain each item in accordance with the manufacturer's instructions, protect it against damage by other trades and adjust, clean and lubricate it on completion of the Works

not fix hardware until background finishes are complete. Door hardware previously fixed shall be removed before any background painting or finishing process.

X110 DESIGNS, MATERIALS AND FINISHES:

regardless of other provisions, materialsand components shall meet fire safety requirements and not be subject to bimetallic corrosion with background materials or other hardware

every finished surface of one material, whether extruded, rolled, cast or stamped, shall match exactly in colour and texture. All items on a visible door face shall be finished identically

Finishes of door hardware shall be:

stainless steel Grade 316 (18/10/3) molybdenum bearing grade satin no. 4 finish

X115 CATALOGUE REFERENCES: door hardware and ironmongery product and catalogue references when indicated on Drawings or referred to in the Specification are indicative only of the quality, style, size and shape required. All hardware and ironmongery samples when submitted shall conform to the specification requirements and are to be supplied complete with all associated and relevant components, mountings, fixings and accessories intended to be installed in the finished work.

X125 FIXING DEVICES:

Provide suitable, matching, metric sized, rust-proofed positive fixing devices to suit the location and background, of Allen key, 'Supadriv', ' Posidriv' or equivalent positive locating drive types.

Fixings for metal doors and/or door frames shall be bolts or self tapping screws.

X130 FIRE RESISTING AND EMERGENCY EXIT DOORS:

hardware and ironmongery to fire rated door assemblies is to be of types and materials which will not compromise the specified fire rating. Fire and smoke control doors, escape route doors and final exits shall all have a controlled door closing device.

hardware and ironmongery to fire rated doors shall be of approved types, independently certified by an approved independent testing laboratory for specified fire ratings under BS 476-22

if lever handles are used on escape routes, provide special unobtrusive, non-toxic, non-radioactive, moulded polycarbonate luminous rose surrounds or insert escutcheons to store natural or artificial light and if lights fail, emit a bright luminosity for up to 8 hours. These shall be to DIN 67510, green, measured value FL.2.1-280 and 2.10 mcd/m2 minimum luminous density one hour after excitation.

X135 DOOR STOPS: all door stops shall be robust and match other hardware items on the door. Provide rubber inserts, which can be easily replaced using simple tools.

On inward opening individual toilet, WC or shower cubicle doors, use buffer hat and coat hooks.

X140 HINGES: pivots and hinges shall be to BS EN 1935 class 3-7-4-0-1-3-0-13 for internal doors no fire and no burglar rating, class 3-7-6-1-1-4-1-13 for internal doors with fire rating, with burglar rating. Hinges shall be of a suitable type and matching otherhardware items on the doors. All hinges are to be of grade 316 satin stainless steel finish, fire rated, independently tested and certified to BS EN 1935 as not compromising the specified fire rating and suitable for the door weight, size and usage intended. Hinges shall be low friction fully lubricated corrosion and maintenance free type butts. The bearing surfaces caged with the bearing housing of the same material as the hinge.

X145 LOCKS AND LATCHES: lock suites for use on fire rated door assemblies shall be independently tested and certified as not compromising the specified fire rating and shall not contain plastics, zinc or other low melting point components. Mortice locks are to be to the performance requirements of BS EN 12209 :

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
|---|---|---|---|---|---|---|---|---|---|---|
| 2 | S | 6 | 1 | 1 | E | 5 | A | A | 2 | C |

in addition locks shall have:

deadbolts incorporating anti-sawing hardened steel rollers

if for lever handles, special springing against progressive lever droop (levers with sprung roses are unacceptable due to potential for damage and corrosion)

if for knobs, soft springing with two way action and 70 mm minimum backset

facility for full reversal of hand, without opening the case

suitable fore-ends, strike plates and rebate components, if for rebated meeting stiles, of non-corroding materials, to match handles (including coloured finishes).
five pin cylinders with double paracentric keyways and triple grooved anti-pick and hardened anti-drill pins finished to match handles and trim (includes coloured finishes), easily removable with the door open, without dismantling trim but not removable if closed. Two keys per cylinder.

high security cylinders are to be to BS EN 1303 and shall be 6 pin double locking types, with practically infinite differs, incorporating the features described for the five pin cylinders and additionally multiple side pins with keys subject to a manufacturer's CARS (Computer aided registration system) key registration system and for which blanks are not available.

Unless otherwise stated, locks shall be master keyed to a system of master suites, without compromise to security standards.

Cylinders shall also be construction keyed with ten keys for the Contractor's use. On completion, turning a master key in a lock shall negate all construction keys. Master and differ keys shall be supplied direct to the Engineer or Employer in a sealed container and shall be accompanied with pre-configured software to enable the proper management of the system by the end user.

provide and deliver the following keys to the Engineer:

three (3) keys for each lock
one (1) blank for each lock
five (5) masterkey for each system
twelve (12) construction keys.

X160 DOOR FURNITURE:

knob and lever furniture shall be non-sprung types to BS EN 1906, with special self lubricating nylon grommets between knobs or levers and roses or backplates. Backplates shall be 3mm thick. Roses shall project no more than 4mm from the door face , with concealed fixings.

levers shall be stainless steel, unless otherwise specified.

spindles for furniture shall be corrosion proofed hardened steel HT material and of lengths suitable for door thickness. If half sets of furniture are to operate locks, use special spindles, which do not require piercing the door's outer face

pull handles shall have either bolt through fixings with seating cups concealed by push plates on the reverse face, or back to back fixings as appropriate. Face fixed pulls are acceptable if their use cannot be avoided

on general circulation doors, use standard 25mm diameter pulls. For doors to rooms, use pulls on a single rose or backplate such that the assembly is identical to a lever handle and rose or backplate on other doors. Lever handles with "fix-dead" spindles are unacceptable, due to the potential for forcible damage.

X170 PANIC EXIT DEVICES

horizontal bar operated panic exit devices, except to single leaf doors in service areas accessible only to maintenance staff, shall be easily reversible, low projection, touchbar type to BS EN 1125 Grade 3-7-6-B-1-3-2-2-B-B, with secret "hold unlocked" facility and photoluminescent "in bar" signage to BS 5499. Panic

latches shall have mortice type latches as specified for heavy duty/high security locks herein:

panic exit devices to pairs of doors shall not allow escape to be prevented by padlocking a chain around a cross bar or other components.

horizontal bar operated panic exit devices to single leaf doors in service areas accessible only to maintenance staff may be standard projection, push bar type to BS EN 1125 Grade 3-6-6-B-1-3-2-2-A-B

where required, panic exit devices shall incorporate local alarm, remote monitoring and/or motor operation. Clauses B.2 and B.3 of BS EN 1125 do not preclude the use on fire rated assemblies of devices without automatic relatching and/or with dogging mechanism. Manufacturers of fire rated assemblies to receive such devices shall provide test data to show that latchless assemblies have been successfully fire tested.

## X175 CONTROLLED DOOR CLOSING DEVICES

door closing devices shall be fully adjustable, hydraulic check types, including mechanical and/or electromagnetic stand open and delayed closing. Provide a ten year guarantee, as specified, for use in local ambient conditions, including exposed positions and, in the case of back check closers, even with no stop fitted.

closures shall be tested to BS EN 1154 and classified as follows: 4-8-2/6-1-1-3

all closers for fire rated doors shall be shown, by testing to BS EN 1154 Category of Use 4, to close a door and positively latch doors from up to 180 degrees.

where specified, provide special function closers. If stand open type is specified on non-fire rated doors, provide suitable special arms. Backcheck and/or delayed closing, where specified, shall be to BS EN 1154

surface closers shall have visually pleasing plain rectangular stainless steel bodies, 50 mm maximum projection, with no permanent, visible markings (except as required by relevant standards) and finished identically to other items on the door. They shall suit doors of either hand.

surface closers, except to service areas accessible only to maintenance staff, shall achieve Class 4-8-5-1-1-3, power adjustable for doors 750 - 1250 mm wide and 20 -100 kg mass, or equivalent grade to Table 2 of BS EN 1154 for doors of greater or lesser width/mass. They shall incorporate adjustable, hydraulic backcheck.

| | | | | | |
|---|---|---|---|---|---|
| 4 | 8 | 5 | 1 | 1 | 3 |

surface closers to service areas accessible only to maintenance staff shall achieve Class 4-8-3-1-1-3, for doors 850 – 950 mm wide and 40 – 60 kg mass or equivalent grades to Table 2 of BS EN1154 for doors of greater or lesser width/mass.

door mounted overhead concealed closers shall be achieve Class 3-8-3-1-1-3, for doors 850 – 950 mm wide and 40 – 60 kg mass, or equivalent grades to Table 2 of BS EN 1154 for doors of greater or lesser width/mass.

floor springs shall be heavy duty, adjustable, hydraulic check types, with thermo-constant stabilising fluid. Visible components and accessories shall match other hardware. Floor springs shall have built-in levelling device and micro-adjustable toe-in and centering device.

floor springs for main circulation routes, auditoria and other heavy use locations shall achieve Class 4-8-5-1-1-3, power adjustable for doors 750 – 1400 mm wide and 20 – 120 kg mass, or equivalent grade to Table 2 of BS EN 1154 for doors of greater or lesser width/mass. They shall incorporate adjustable, hydraulic backcheck

floor springs for light use locations shall achieve Class 4-8-3-1-1-3, fixed power for doors 850 – 950 mm wide and 40 – 60 kg mass, or equivalent grades to Table 2 of BS EN 1154 for doors of greater or lesser width/mass. They shall incorporate hydraulic backcheck operation.

electromagnetic fire hold closers shall be to BS EN 1155 and be of the same design, finish and standards as other closers but shall allow the door to:-

hold open electromagnetically when set and, on receipt of a signal from a central fire alarm or other device, automatically release and properly close.

close immediately if physically pushed to, if an integral fire officer test button is pressed, or if power fails.

wiring to electromagnetic fire hold closers shall be carried between frame and door leaf by conductor hinges or concealed fixing flexible metal cable loops.

power sources for fire hold closers shall be Class II Safety Isolated Transformers to BS 3535. If fire alarm systems do not incorporate clean contacts, transformers shall incorporate relay control interfaces.

if both leaves of a pair of doors have closers and one must close first, due to rebated stiles, latchbolts etc, provide suitable matching selectors which do not obstruct hardware or affect fire ratings.

X180 BOLTS: provide bolts at top and bottom of one leaf of a locking double door. Top bolts shall have suitable plates or keeps and bottom bolts shall have dirt excluding or easy clean sockets. Unless otherwise stated, top bolts shall be 300 mm long and bottom bolts 228 mm long:

bolts generally shall be of a high quality flush type, with dovetail returns to resist door damage. They shall have projecting slides where escape may be required and lever action in other locations

bolts to plant rooms and duct doors shall be of a good quality anodised aluminium surface type. If door opens outwards, top bolts shall be necked to allow proper fixing

WC cubicle indicator bolts shall be mortice type, unless door/frame details are unsuitable, when surface types will be permitted. They shall have red/white outside indicators and coin operated stainless steel heat emergency releases.

X185 DOOR SIGNS refer to Section X10.

X190 PROTECTION PLATES / PUSH PLATES:

unless otherwise specified, stainless steel plates shall be 2 mm thick.

fix plates with suitable countersunk screws located 5 mm from edges, with screws at each corner and equally spaced, not more than 240 mm apart, to top and bottom edges. The Contractor shall site check required plate sizes before ordering.

## M25:Y ELECTRONIC DOOR ACCESS SYSTEM

### M25:Y1 GENERALLY

Y105 DESCRIPTION OF WORK: installation of a complete door access system for Hotel guest rooms, health club, employee entrance, etc., including but not limited to the following:

system central processing unit
check-in terminals
card encoders
portable lock interrogation and programming unit
electronic locks and keycards
POS readers/verifiers
hardware and software integration with the Hotel Management System.

Y110 SAFETY: the lock shall have the following features:

it shall not be possible to tamper with, to gain access to the room

card code is password protected

code is not visible and cannot be copied

new guest card cancels previous one up to level 6 (reference made to access level section).

door can only be opened after complete removal of the card from lock

door automatically relocks after 4-6 seconds

guest card can be programmed with expiry date.

maid can cancel guest cards in checked out rooms

insertion of new master card cancels all previous masters and sub-masters

service cards for limited time periods can be issued

100 last guestroom entries can be read and printed out via lock interrogator unit. Repetitive entries within short time periods should be recorded as one entry only, so as not to load up the memory with multiple card insertions by guests unfamiliar with the lock or not successful at first attempt to open.

Y115 TESTS: equipment is to be tested for quality and operation at factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Engineer before dispatch to site.

Y120 APPROVED MANUFACTURERS: obtain door access system from

Man: Vingcard (Norway)
Man: Nexus (Japan)
Man: Tesa (Italy)

or other equal and approved.

M25:Y2 SYSTEM DESCRIPTION

Y205 GENERAL: the door access system is to utilize electronic recodable locks operated by standard magnetic stripe keycards to control access to Hotel guest rooms, health club and other areas of the Hotel. Upon check-in, the guest is issued with the keycard that allows him access to his room and to other specific areas of the Hotel during his period of residence in the Hotel.

Y215 KEYCARD ENCRYPTION: when coded, the card is given an authorized starting (check-in) time and a finishing (check-out) time, or an issue time so that cards can be issued non-sequentially and from more than one location. Entry is refused outside the authorized time window. It is to be possible to issue keycards up to 12 months in advance so that groups of persons can be sent room keys when reservations are confirmed avoiding long check-in queues. Each keycard is to be encrypted with a unique code. Card code is not to be visible, not to be copied and is to be password protected. No false cards are to be generated.

if a pre-issued cardholder fails to arrive, a real time override feature is to ensure that the pre-issued card is invalidated by a later issued keycard

it shall be possible to reverse a suite card being used to access several rooms to separate entries.

Y220 RECODABLE LOCKS: when a guest inserts the keycard into the lock for the first time, the lock is to be immediately recoded canceling entry authorization for previous guest's keycard. Multiple keycards can be issued to one party and they are to be used to open doors throughout the Hotel such as that of the health club, employee's entry, etc.

Each valid guest keycard is to be encoded with a sequential number with lockset always looking ahead for next sequence. If keycard is unused the lock is to be pre-programmed ahead for a certain number of skips (10 cards) to allow the new one to access without sequencing problems. This is known as sequential skip. Sequence correction cards shall allow sequence locks to operate again.

M25:Y3 COMPONENTS

Y305 SYSTEM CPU: this is a multi-tasking, IBM compatible, personal computer located in the Front office to control the issuing of keycards, administer passwords and maintain the audit trail of all day-to-day transactions and programming:

access to the system is protected by high level passwords and the system manager can determine precisely what functions each operator is allowed to perform. Software is to be user friendly with pop-up menus and on-line help.

system PC is to register each transaction with the following details:

ID number and name of user
date and time
terminal used
level, number and type of issued cards
access and modification of user list.

also, it provides the following minimum reports and print outs for different periods ( last 24 hours, specific days, week, month):

list of all transactions
list of all transactions for specific locks
list of all transactions per user
user list with corresponding authority levels
configuration list per section, zone or area

Y315 CHECK-IN TERMINALS: four mini-terminals linked to system CPU are to be used. The check-in terminals are to issue keycards but they are not to change system set-up:

terminal screens are to black out after a few minutes if the keyboard is not used.

Y325 CARD ENCODER: five card encoders are to be connected via network nodes one for each check-in terminal and one connected to the system CPU (card issuing computer):

the card encoder is motor-driven for rapid card encoding and verification. It should be able to write standard data on one of the three tracks of the keycard as well as additional data on the other two tracks for use by Point-Of- Sale (POS) terminals.

staff are issued with keycards which give them access to designated guest rooms only when they are on duty.

Y335 PORTABLE LOCK LINK (INTERROGATION & PROGRAMMING UNIT): when plugged into any lock in the Hotel, this unit is to allow reprogramming the lock after failure or replacement, viewing and downloading the last 100 lock events from the entry log audit trail. It is battery powered with an optional external power pack in case of lock battery failure. Repetitive entries within short time periods should be recorded as one entry only, so as not to load up the memory with multiple card insertions by guests unfamiliar with the lock or not successful at first attempt to open.

Y345 ELECTRONIC KEYLOCKS: each electronic lock is to be completely independent and stand-alone with no need for wiring to a central computer. Except in emergencies, the lock is to be opened only by standard magnetic stripe cards issued to staff as well as guests:

the lock is to be powered by standard alkaline batteries guaranteed to last at least two years. A warning light indicating low power is to be issued when staff cards are inserted three months before battery replacement. Replacement of batteries should only be possible with special tools

the lock is to contain a card reader and an electronic control module connected to a motor actuated mechanism:

the lock control module shall be a stand-alone microcomputer. This means that the hotel room security system is to be controlled by software resident in the locks, activated by cards coded in the card issuing computer

the card reader is to read only when the card is removed for reliable first time reads and added security as the card won't be left in. Door automatically relocks after 4-6 seconds.

an override cylinder will allow the door to be opened in life-threatening emergencies using a high security master key

the lock should be a heavy duty double locking mortice type, fire rated to at least the same level as that of the door. It is not to be possible to tamper with the lock to get access to the room

In addition to the above, the lock must have the following features:

dead locking

latch bolt with 19 mm throw and anti-friction nylon insert for easy and quiet closing

door knob. Lever only for handicapped rooms

deadbolt of solid steel extruding at least 25 mm with a minimum of 10 mm remaining inside the lock

panic release lever to retract the latch and dead bolts simultaneously

solid mechanism inside for the retraction of the dead bolt

panic release lever

indication on the corridor if double locked by guest (for privacy).

the lock must satisfy interior design requirements with regard to available finishes and general appearance. It should be attractive and look almost similar to conventional locks to avoid confusion by guests.

disassembly and assembly should be easy. Installation should be simple and not require specific individual adjustments.

it is to be possible to deactivate the lock to permit continuous access (for renovation purposes for example).

Y350 KEYCARDS: high quality ANSI or ISO re-usable cards with 3 track wide magnetic stripe, standard credit card size. The card has an insertion message that can be over printed by Hotel or it may be pre-printed with Hotel custom design using hot stamp foils or 4 color lithography. Card must clearly explain with pictogram and arrow how to use it.
Y355 ENTRY LEVELS: provide system as follows and as detailed on the Drawings.

Y360 INTEGRATION WITH PROPERTY MANAGEMENT SYSTEMS (PMS): the card lock system is to be integrated with the Hotel PMS by employing the proper integration software and hardware. In this way, it will be possible to issue cards in advance whenever the reservation is made. Integration eliminates the risk of selling the same room twice or selling rooms before they are made up:

integration allows other Hotel services to be charged to the guest's account. Two tracks of the keycard are used by the PMS system to control Point-Of-Sale transactions.

Y365 INTEGRATION UNIT: an interfacing unit between the Hotel PMS server computer and the access system computer. The PMS is to take over full control of guest keycard issuing for fast check-in procedures so that check-in terminals described in above become PMS terminals. This will enable system CPU to share information with Hotel's main database and its POS systems. Staff cards will be issued from the access system CPU. If the PMS computer fails, the access system will still operate as a stand-alone system.

Y380 POS READER/VERIFIER: this device is to be used in conjunction with a mini-terminal in a stand-alone configuration in restaurants and other similar places to check guest's identity.

Y390 EMERGENCY REQUIREMENTS: in case of an emergency, the following facts should hold:

door can be opened in case of battery or power failure. Back up cards are available for the entire hotel.

door can be retracted from inside via standard panic hardware mechanism

double locked rooms can be opened with the emergency card

there will be no loss of memory in case of battery change

when the lock fails, the procedure to open a room is simple and uncomplicated without compromising the safety of the system.

M25:Y4 ELECTRONIC LOCKS

Y405 ELECTRONIC LOCKS: each electronic lock is to be wired to a central computer. Except in emergencies, the lock is to be opened only by proximity cards issued to staff:

The lock is to be powered by DC supply from the network controllers in addition to being equipped with standard alkaline batteries guaranteed to last at least two years. A warning light indicating low power is to be issued when staff cards are inserted three months before battery replacement. Replacement of batteries should only be possible with special tools. The lock hardware should be interfaced with the proximity card reader units.

Locks shall be operated by magnetic cards from two sides or by magnetic cards from one side and lever on the other side as indicated on electrical drawings.

WORKMANSHIP

M25: 1 GENERALLY

1051 WORKMANSHIP GENERALLY including fabricating, welding, brazing, machining assembling and fixing are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

1101 FIRE RESISTANCE: the specified performance is to be the minimum period attained when tested for integrity in accordance with BS 476-20 and 22.

1551 PROTECTION OF COMPONENTS: do not deliver to site components which cannot be put immediately into suitable clean, dry, floored and covered storage. Stack near vertical on level bearers, separated with spacers to prevent damage by and to attached ironmongery and other component projections.

M25:2 FIXING DOOR HARDWARE

2101 DOOR HARDWARE: assemble and fix carefully and accurately using fastenings with matching finish supplied by hardware manufacturer. Prevent damage to hardware and adjacent surfaces. At completion check, adjust and lubricate as necessary to ensure correct functioning.

M25:3 ELECTRONIC DOOR ACCESS SYSTEM:

3101 EQUIPMENT INSTALLATION:

install equipment in accordance with manufacturer's instructions and to the approval of the Engineer. Mount equipment in alignment with other building fixtures and fix firmly in place with all supports and fastenings secured.

equipment is to be installed to prevent electromagnetic, electrostatic or other outside interference impairing system performance.

equipment is to be installed to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made, but no changes are to be made without prior approval.

surfaces of equipment damaged during installation are to be made good, using touch-up paint provided by equipment manufacturer, to the satisfaction of the Engineer.

routing of data cables and power cables, in general, is to be in separate raceways

start up the system and ensure that it is operating properly.

the Contractor shall provide a certificate from the equipment manufacturer, confirming that he has received proper training and acquired the necessary skills to undertake the installation

coordinate closely with the PMS installer.

3201 TESTING AND TRAINING:

superintendance: the equipment manufacturer is to provide an engineer and technician qualified in the operation of the system and equipment performance and the requirements of the Specification, to assist the Engineer to test and verify the system performance

training: before the date of substantial completion, provide the Employer's staff with a comprehensive training course concerning operation and maintenance of the access system

3301 SPARE PARTS AND MAINTENANCE:

provide a set of key cards for an entire year operation.

provide replacement batteries for a period of five (5) years operation.

provide five percent (5%) spare locksets and parts.

maintenance contracts: submit supplementary proposals for annual maintenance contracts. The proposals are to:

include for maintaining the installations in efficient working order including routine and emergency service checks, adjustments, lubrication(of locks) and the supply and replacement of defective and damaged parts, consumables, etc.

set out the terms of the offer, the work to be carried out, the guarantees of performance and the price of the work or part thereof for the first twelve months after substantial completion.

## PART 1 - HARDWARE SET:

**GENERAL NOTES:**

1. Hinges at all out swing doors with locksets shall have non-removable pins with stainless steel ball bearings.

2. Verify all lock functions with owner prior to ordering.

3. All cylinders to be integrated with master key system.

4. Satin finished Stainless steel kick plates from both sides, to be supplied to all public toilets, janitor closets and pantries. Dimensions to be 200mm high x 100mm less than door

5. Push/pull plates not to be less than 90mm wide x 380mm long.

6. Floor and wall door stops to be supplied where applicable.

7. Floor mounted door stops to be similar to IVES FS436 Dome Stop

8. Wall mounted door stops to be similar to IVES WS402CVX

9. All external doors to have weather-strip.

10. Hardware for fire rated doors are indicative, door to be fully assembled by approved manufacturer.

11. All Fire Exit doors shall be fitted with exit device on the internal side and door closes on the external Side shall be lockable type.

12. All fire-rated doors to have self closing devices and smoke seal.

13. Closers on any fire-rated door shall be labeled as having same fire resistance as door.

14. All mentioned hardware items are the minimum requirements. In case of conflict between the requirements of this section and the client approved specifications; the more stringent requirements shall take precedence.

15. All hardware to be supplied similar to the required or approved equal.

**HARDWARE SETS:**

**HW1/F :** Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise apartment entrance lockset, ANSI type F09 | L9060 | 630 | Schlage | each | 1 |
| Lever handles | 02 - L Series | 630 | Shlage | each | 1 |
| Knob | 41(D PLYMOUTH) | 630 | Shlage | each | 1 |
| Door closer, concealed | 330 series | 689 | LCN | each | 1 |
| Automatic door bottom | 730S | Silicon | Hager | each | 1 |
| Smoke seal | 723W | To match frame color | Hager | set | 1 |
| Door stop, wall/floor mounted-where | Refer to | 630 | IVES | each | 1 |

| | | | | | |
|---|---|---|---|---|---|
| applicable | general notes | | | | |
| Eye viewer | U698 | 652 | IVES | each | 1 |

**HW 2:**

Each

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise privacy lockset, ANSI F02 | L9044 | 630 | Shlage | each | |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Coat hook | 571 | 626 | IVES | each | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |

**HW3:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise dormitory / bedroom lockset, ANSI F21 | L9473 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |

**HW4:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise passage latch, ANSI F01 | L9010 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |

**HW 5:** door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ,ANSI A5111 | BB1199 | 630 | Hager | each | 3 |
| Rim panic exit device | F-18-R-L | 630 | Monarch | each | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Lever handles | Sutro | 630 | Monarch | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

**HW 5/F:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ,ANSI A5111 | BB1199 | 630 | Hager | each | 3 |
| Rim panic exit device | F-18-R-L | 630 | Monarch | each | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Lever handles | Sutro | 630 | Monarch | each | 1 |
| Smoke seal | 723W | To match frame color | Hager | set | 1 |
| Automatic door bottom | 730S | Silicon | Hager | each | 1 |

**HW6:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise store room lockset, ANSI F07 | L9080 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

**HW6/F:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise store room lockset, ANSI F07 | L9080 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Automatic door bottom | 730S | Silicon | Hager | each | 1 |
| Smoke seal | 723W | To match frame color | Hager | set | 1 |

**HW7:**

of door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 6 |
| Mortise store room lockset, ANSI F07 | L9080 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 2 |
| Manual flush bolt | 282D | 626 | Hager | each | 1 |
| Dust proof socket | 280X | 626 | Hager | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

**HW7/F:**

Each pair of door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 6 |
| Mortise store room lockset, ANSI F07 | L9080 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 2 |
| Automatic door bottom | 730S | Silicon | Hager | each | 2 |
| Smoke seal | 723W | To match frame color | Hager | set | 2 |
| Manual flush bolt | 282D | 626 | Hager | each | 1 |
| Dust proof socket | 280X | 626 | Hager | each | 1 |

**HW 8:**

Each pair of doors to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ,ANSI A5112 | BB1191 | 630 | Hager | each | 6 |
| Mortise Classroom Deadlock ,ANSI type E06021 | L960 | 630 | Shlage | each | 1 |
| Pull handles, meets ANSI A156.6 for J401 pull | Security pull P4E | 630 | Hager | pair | 2 |
| Manual flush bolt | 282D | 626 | Hager | each | 1 |
| Dust proof socket | 280X | 626 | Hager | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

**HW9:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise office lockset, ANSI F04 | L9050 | 630 | Shlage | each | 1 |
| Lever handles | 02- L Series | 630 | Shlage | pair | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | 630 | IVES | each | 1 |

**HW 10:**

Each pair of doors to have

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ,ANSI A5112 | BB1191 | 630 | Hager | each | 8 |
| Mortise Classroom Deadlock ,ANSI type E06021 | L960 | 630 | Shlage | each | 1 |
| Pull handles, meets ANSI A156.6 for J401 pull | Security pull P4E | 630 | Hager | pair | 2 |
| Manual flush bolt | 282D | 626 | Hager | each | 1 |
| Dust proof socket | 280X | 626 | Hager | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

**HW11:**

Each pair of doors to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4",ANSI A5111 | BB1199 | 630 | Hager | each | 6 |
| Panic exit with reversible vertical rod device | 18-V-LBR | 630 | Monarch | each | 1 |
| Panic exit with reversible vertical rod device | 18-V-LBR-“BA”-SUTRO | 630 | Monarch | each | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Thumb piece | Standard T 1302 | 630 | Monarch | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

**HW11/F:**

Each pair of doors to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4",ANSI A5111 | BB1199 | 630 | Hager | each | 6 |
| Panic exit with reversible vertical rod device | F-18-V-LBR | 630 | Monarch | each | 1 |
| Panic exit with reversible vertical rod device | F-18-V-LBR--“BA” | 630 | Monarch | each | 1 |
| Door closer, surface mounted | 4040 with designer series metal | 689 | LCN | each | 1 |

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| | cover | | | | |
| Lever handle | Sutro | 630 | Monarch | each | 1 |
| Automatic door bottom | 730S | Silicon | Hager | each | 2 |
| Smoke seal | 723W | To match frame color | Hager | set | 2 |

**HW 12/F:**

Each door to have:

| | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4"", ANSI A5111 | BB1199 | 630 | Hager | each | 3 |
| Mortise classroom lockset, ANSI F05 | L9020 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |
| Automatic door bottom | 730S | Silicon | Hager | each | 1 |
| Smoke seal | 723W | To match frame color | Hager | set | 1 |

**HW13/F:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½”x4”, ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise store room lockset, ANSI F07 | L9080 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Door protection plate - Kick Plate | 8400 series | 630 | Ives | each | 1 |
| Door protection plate - Mop Plate | 8400 series | 630 | Ives | each | 1 |
| Automatic door bottom | 730S | Silicon | Hager | each | 1 |
| Smoke seal | 723W | To match frame color | Hager | set | 1 |

**HW14:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4½",ANSI A5111 | BB1199 | 630 | Hager | each | 3 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Door protection plate - Kick Plate | 8400 series | 630 | Ives | each | 1 |
| Door protection plate - Mop Plate | 8400 series | 630 | Ives | each | 1 |
| Pull handle | TG9335 | 630 | Dorma | each | 1 |
| Push plate | 8200 | 630 | Ives | each | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | Ives | each | 1 |

**HW15:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4½",ANSI A5111 | BB1199 | 630 | Hager | each | 3 |
| Mortise Classroom Deadlock ,ANSI type E06091/E16091 | L9464 | 630 | Shlage | each | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Door protection plate - Kick Plate | 8400 series | 630 | Ives | each | 1 |
| Door protection plate - Mop Plate | 8400 series | 630 | Ives | each | 1 |
| Pull handle | TG9335 | 630 | Dorma | each | 1 |
| Push plate | 8200 | 630 | Ives | each | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | Ives | each | 1 |

**HW16:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4½",ANSI A5111 | BB1199 | 630 | Hager | each | 3 |
| Mortise Classroom Deadlock ,ANSI type E06091/E16091 | L9464 | 630 | Shlage | each | 1 |
| Door closer, Concealed | 330 series | 689 | LCN | each | 1 |
| Pull handle- back to back | 974B | 630 | Hager | each | 1 |

**HW 17:**

Each pair of doors to have

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ,ANSI A5112 | BB1191 | 630 | Hager | each | 6 |
| Mortise Classroom Deadlock ,ANSI type E06021 | L960 | 630 | Shlage | each | 1 |
| Pull handles- back to back | TG 357- 500 ctc | 630 | DORMA | pair | 2 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 2 |
| Manual flush bolt | 282D | 626 | Hager | each | 1 |
| Dust proof socket | 280X | 626 | Hager | each | 1 |
| Roller latch | 318D | 626 | Hager | each | 1 |

**HW 18:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing swing clear hinges 4½"x4", ANSI A5121 | BB1361 | 630 | Hager | each | 3 |
| Mortise privacy lockset, ANSI F02 | L9044 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |

**HW 19:**

Each door to have

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4" ,ANSI A5112 | BB1191 | 630 | Hager | each | 3 |
| Mortise Classroom Deadlock ,ANSI type E06021 | L960 | 630 | Shlage | each | 1 |
| Pull handles- back to back | TG 357- 500 ctc | 630 | DORMA | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 2 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |

**HW 20:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Rising butt hinges 4½"x4" | RH6191 | 630 | Hager | each | 3 |
| Mortise privacy lockset, ANSI F02 | L9044 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Coat hook | 946P | 652 | Hager | each | 1 |
| Door stop, wall/floor mounted-where applicable | Refer to general notes | Rubber | IVES | each | 1 |

**HW 21:**

Each door to have:

| ITEM | CODE | FINISH | MAN. | UNIT | QTY |
|---|---|---|---|---|---|
| Ball bearing butt hinges 4½"x4", ANSI A5112 | BB1191 | 630 | Hager | each | 4 |
| Mortise store room lockset, ANSI F07 | L9080 | 630 | Shlage | each | 1 |
| Lever handles | 02-L Series | 630 | Shlage | pair | 1 |
| Door closer, surface mounted | 4040 with designer series metal cover | 689 | LCN | each | 1 |
| Weather-strip | 736 | To match door finish | Hager | set | 2 |

# M31 STAIRS, BALUSTRADES AND SUNDRY ITEMS

## GENERAL

### M31:A SCOPE

A105 SCOPE: this Section is for the specification of pre-assembled metal stairs, balustrades, railings and the like and sundry items of metal not included in other sections of the Specification. Steel stairs and staircases fabricated and framed as part of structural steelwork are included in Section F11 of the Specification.

### M31:C SUBMITTALS

C105 SHOP DRAWINGS: submit shop drawings showing fabrication and installation details of each type of stair, balustrade and railing indicated, including but not necessarily limited to the following:

plans, elevations and sections

profiles and dimensions of individual components

details of typical composite members, including reinforcement, stiffeners and methods of jointing and connection

glass and glazing details

data on accessories and finishes

construction and installation details, including anchorages

co-ordinate for anchors and bolts specified for installation under other Sections

include structural analysis data for installed products required to comply with structural performance requirements and obtain approval prior to manufacture or delivery.

C110 SAMPLES: within the programmed time submit samples of the specified products, being part of the quantity required for the project. Obtain approval of appearance and other relevant characteristics before proceeding with manufacture or delivery.

M31:D PERFORMANCE REQUIREMENTS

D105 HANDRAILS AND RAILINGS: engineer, fabricate, fix and install handrails and railing systems to comply with requirements of ASTM E 985 for structural performance based on structural computations that demonstrate compliance with ASTM E 985.

D110 GRATINGS: engineer, fabricate, fix and install gratings to support the required loading. Gratings required to support vehicular traffic shall be capable of supporting the required wheel loads for the type of vehicles indicated on the drawings.

MATERIALS AND PRODUCTS

M31:E COMPONENTS

E105 METAL COMPONENTS of composite units, including fastenings, fixings, treatments, finishings, coatings and jointing materials are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

M31:H STAIRS, BALUSTRADES AND THE LIKE

H535 ACCESS LADDERS: to BS 4211, mild steel with galvanised finish, consisting of flat bar stringers and round single bar rungs, with handrails and safety hoops, as shown on the Drawings, welded or riveted and bolted together and supplied complete with accessories and fixings.

H536 ACCESS LADDER SAFETY CAGES: Fabricate ladder safety cages to comply with ANSI A14.3. Fabricate from same metal as ladders to which safety cages are attached. Fasten assembled safety cage to ladder rails and adjacent construction by welding or with stainless-steel fasteners unless otherwise indicated.

H545 STEP RUNGS: 20 mm diameter mild steel rungs with galvanised finish, to be inserted in concrete structure.

H650 BALUSTRADES AND RAILS: galvanised steel pipe railing system that can be assembled and joined by concealed mechanical fasteners at intersections without welding. Components are to be joined with structural adhesive at splice joints.

Galvanised steel posts and rails are to be fabricated from ASTM A53/ A53M, Type S, Grade B Schedule 40 pipes.

Fittings are to be manufactured of steel hot dip galvanised after fabrication. Tee fittings and elbows, which are fabricated from more than one piece, are to be of welded construction with no weld marks visible when the fitting is installed. All surfaces which mate with pipe or tubing, shall be precisely machined and free from burrs.

All mechanical fasteners used in the assembly shall be of cadmium-plated steel or austenitic stainless steel. Exposed mechanical fasteners are to be of matching material and finish to the item being fixed.

An approved two-part epoxy compound as recommended for particular purpose and application by the manufacturer shall be used for permanent splice connections.

Man: R & B Wagner Inc.

or other equal and approved.

## M31:J METAL SUNDRY ITEMS

J105 ROOF SCUTTLE: fabricate access hatch units of sizes, type and shape shown on drawings, for 1.9 kPa external loading and 0.96 kPa internal loading pressure. Fabricate from Zinc-coated steel sheets, commercial quality with 0.20 percent copper, ASTM A 653M, Z275, hot-dip galvanised, mill phosphatized. Frame with 230 mm high integral-curb double-wall construction with 40 mm insulation, cant strips and cap flashing (roofing counter-flashing), with welded or sealed mechanical corner joints. Provide double-wall cover (lid) construction with 25 mm insulation core. Fasteners are to be from same metal as metals being fastened, or nonmagnetic stainless steel or other non-corrosive metal as recommended by manufacturer. Match finish of exposed fasteners with finish of material being fastened. Where removal of exterior exposed fasteners affords access to building, provide non-removable fastener heads. Equip units with complete hardware set including hold-open devices, interior padlock hasps, and both interior and exterior latch handles. Provide tubular or fingered neoprene gasketing.

Man: Bilco [http://www.bilco.com/]

or other equal and approved.

J210 WATERTIGHT FLOOR DUCT COVERS: solid steel plate covers and angle frames with zinc coated finish, with neoprene sealing strips on underside of cover, stainless steel locking screws and keyholes, removable cover supports and lugs on frame for building in.

Man: Glynwed Brickhouse (Saint-Gobain Pipe Division).

or other equal and approved.

J215 WATERTIGHT MANHOLE COVERS: non-rocking, cast iron manhole covers and angle frames to BS EN 124, with machined seating and double seal to provide watertight seal.

Man: Glynwed Brickhouse

or other equal and approved.

J220 FLOOR TRAP COVER: steel pan constructed from galvanised steel sheet to BS EN 10143 to receive finish same as adjoining flooring. Provide metal border strip with neoprene gasket all around the cover. Steel angles and T sections supporting the covers are to be hot rolled sections to BS 4-1 and BS EN 10056-1 hot dip galvanised.

J226 CHANNEL COVER: made from 6 mm thick galvanised chequered steel plate with steel angle frame to BS 4 and BS EN 10056-1 hot dip galvanised. Provide with neoprene sealing strips on underside of cover, stainless steel locking screws and keyholes, removable cover supports and lugs on frame for building in.

J230 ACCESS HATCH: fabricate access hatch units of sizes, type and shape shown on drawings, for 1.9 kPa external loading and 0.96 kPa internal loading pressure. Steel cover constructed from galvanised steel sheet to BS EN 10143. Steel angles and T sections supporting the covers are to be hot rolled sections to BS 4 and BS EN 10056-1 hot dip galvanised. Fasteners are to be the same metal as metals being fastened, or nonmagnetic stainless steel or other non-corrosive metal as recommended by manufacturer. Match finish of exposed fasteners with finish of metal being fastened. Where removal of exterior exposed fasteners affords access to building interior, provide non-removable fastener heads. Equip units with complete ironmongery and hardware sets, including interior padlock hasps and interior and exterior latch handles. Provide tubular or fingered neoprene gasketing

J242 GALVANISED STEEL GRATING: medium and heavy duty gratings manufactured from ASTM A 1011M steel electro pressure welded. Gratings are to be hot dip galvanised after fabrication in accordance with ASTM A 123/123M with a coating not less than 610 gm/m2 of coated surface. Bearing bars and cross bars are to be of rectangular section with size and spacing as per manufacturer's written recommendation for the span and type of loading indicated on the Drawings. Heavy duty gratings are to be capable of supporting required wheel loads.

Man: IKG Industries [http://www.ikgindustries.com/]

or other equal and approved.

J510 FIXED ACOUSTICAL ALUMINIUM LOUVER: frames and blades to be 6063-T5 alloy. Fixed blades to be 2.0 mm thick aluminium in combination with fiberglass or mineral wool acoustical insulation protected by a woven fire-retardant (self-extinguishing) 100% polyester sheeting. Fasteners to be aluminium or stainless steel. Structural supports shall be designed to carry the wind load indicated on the Drawings. Free area shall be more than 50%.:

Supply louvers with framed removable aluminium bird screen.

Noise reduction coefficient shall be 7-17 dB between 125 and 8000 Hz.

Man: Construction Specialties [http://www.c-sgroup.com/]
Man: Greenheck [http://www.greenheck.com/]
Man: Industrial louvers [http://www.industriallouvers.com/]

or other equal and approved.

J515 FIXED ALUMINIUM LOUVER: frames and blades to be 6063-T5 alloy. Fixed blades to be 2.0 mm thick aluminium. Fasteners to be aluminium or stainless steel. Blades to be one-piece extrusions with either single drain or dual drains. The frame shall be designed to collect and drain water to exterior at sill by means of channels in the jambs. Sill and jamb frames shall be continuously welded and caulked to prevent water penetration to interior wall construction. Structural supports shall be designed to carry the wind load indicated on the Drawings. Free area shall be more than 50%.

Supply louvers with framed removable aluminium bird screen.

Man: Construction Specialties [http://www.c-sgroup.com/]

or other equal and approved.

J520 SAND TRAP LOUVERS: fixed vertical blade type a minimum of 300 mm deep. Louvers shall be fabricated from extruded aluminium members epoxy coated, a minimum of 2 mm thick of 6063-T5 alloy. The louver sub-sill will be formed from 1.25 mm thick aluminum sheet and sloped at such an angle to direct captured sand to the building exterior. The Louvers shall be tested by an accredited laboratory to indicate the louver system's ability to reject a minimum of 95 percent of sand grain sizes between 150 and 425 microns when subjected to a face velocity of 0.5 meters per second. An indoor screen construction as specified shall be provided on the inside of each louver. Louvers shall provide more than 50% free area.

Man: Construction Specialties [http://www.c-sgroup.com/]

or other equal and approved.

WORKMANSHIP

M31:1 GENERALLY

1051 WORKMANSHIP GENERALLY including fabricating, welding, brazing, machining assembling and fixing are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

M31:2 FIXING

2101 TRIMS AND FINISHINGS are to be in un-jointed lengths between angles or ends of runs. Where running joints are unavoidable obtain approval of location and method of jointing. Mitre angle joints unless otherwise specified.

# P11 PLASTER AND DECORATIVE RENDER COATINGS

## GENERAL

### P11:A SCOPE

A105 SCOPE: this Section is for the specification of cement-sand and gypsum plastering and other decorative thick coating work to walls and ceilings, including associated work and accessories.

## MATERIALS AND PRODUCTS

### P11:L LATHING AND BEADS

L110 EXPANDED METAL LATHING: to BS EN 13658-1-2, plain expanded galvanised steel, weighing not less than 1.6 kg/m2.

Man: The Expanded Metal Company Ltd. [http://www.expandedmetalcompany.co.uk/]
Ref: Expamet BB264

Man: Catnic International [http://www.catnic.com/]

or other equal and approved.

L120 BEADS: galvanised steel plaster beads: plaster stop, architrave and angle beads to BS EN 13658-1-2, for internal work. Use plaster beads made from galvanised steel to BS EN 10143, designation Z2 G450 N passivated, for external work.

Man: The Expanded Metal Company Ltd.
Ref: Expamet

Man: Catnic International.
Ref: Steel Plasterer's beads

or other equal and approved.

L510 TYING WIRE: 1.2 mm diameter (18 swg) annealed iron wire galvanised to BS EN 10244-2.

L620 STAPLES: galvanised steel wire.

L630 WOOD SCREWS: to BS 1210.

## P11:P MIXES, COATINGS AND ADMIXTURES

P112 PLASTERING MIX: aerated plaster for general use comprising:

ordinary Portland cement to BS EN 197-1

sand to BS EN 13139, Table 1 or ASTM C 897

cement-sand proportions shall be adjusted to give compressive strength not less than 5 ±1 N/ mm2

plasticiser to BS EN 934-3 and to approval, to be used with cement-sand mix in proportions recommended by manufacturer.

P115 FACTORY-PREPARED MIX: manufacturer's standard factory-packaged blend of Portland cement, aggregate, water retaining and other suitable admixtures and workability aids conforming to BS EN 998-1-2 and as follows:

| | | |
|---|---|---|
| Lime content | : | nil. |
| | : | sand to BS EN 13139, Table 1 or ASTM C 897 |
| Compressive strength | : | not less than 5 ±1 N/ mm2 |
| Plasticiser | : | to BS EN 934-3 and to approval. |
| Wet mix life | : | as recommended by manufacturer |
| Initial adhesion at 28 days | : | > 0.3 N/mm2 |
| Bending (flexural) strength | : | not less than 1 N/mm2 |
| Minimum cement sand mix | : | 1:3-4 |
| Test | : | BS EN 4551-1-2 BS EN 1015-1> 4, 6, 7, 19 [ASTM C780] |

P410 SPATTERDASH KEYING MIX: one part ordinary Portland cement to BS EN 197-1 and two parts clean fairly coarse sand mixed to a thick slurry and kept well stirred.

For smooth concrete surfaces, add SBR or Acrylic bonding agent per manufacturers' recommendations.

P510 ADMIXTURES: do not use admixtures other than plasticisers and water-retaining agents without prior approval. Do not use admixtures of any type with proprietary mixes. Do not use calcium chloride or any admixtures containing calcium chloride.

P551 BONDING AGENT: styrene-butadiene co-polymer latex (SBR) for use as a waterproof bonding agent and admixture. When used as a bonding agent it shall have adequate pot-life for easy workability. Use strictly as per manufacturer's recommendation.

Man: Fosroc
Ref: Nitobond SBR

Man: Master Builders Technologies/ BASF
Ref: Rheomix 141

or other equal and approved.

P610 WATER: to be clean, free from silt, organic matter, alkali, salts and other deleterious impurities. Obtain approval of source of supply. Test to BS EN 1008.

P710 BITUMEN COATING SOLUTION: to BS 3416, Type 1.

WORKMANSHIP

P11:1 GENERALLY

1051 MANUFACTURERS' RECOMMENDATIONS are to be strictly followed for all materials and products.

1055 INTERNAL PLASTERING is to be executed in accordance with BS EN 13914-2 , as applicable.

1056 EXTERNAL PLASTERING is to be executed in accordance with BS EN 13914-1 , as applicable.

1151 CONTROL SAMPLES: for each type of coating work, complete sample areas, being part of the finished work, in approved locations, size not less than 5 m2 and obtain approval of appearance before proceeding.

1201 UNIFORMITY OF COLOUR AND TEXTURE: once samples of coatings have been approved, do not change type or proportion of constituent materials. Ensure that supplies of materials are sufficient to give consistent and uniform colour and texture. Obtain each material from one source and mix different loads if necessary.

1251 STORE cement, and plaster separately by different types, off the ground, in dry, well ventilated areas. Use in order of delivery and within manufacturer's recommended time limit. Reject any bag which contains caked or partially set material.

1301 MIXING: measure materials by volume using clean gauge boxes. Proportions of specified mixes are for damp sand, adjust proportions if dry sand is used. Thoroughly mix materials dry until uniform in appearance. Add water and mix to a consistency suitable for the work.

1351 MECHANICAL MIXERS: do not mix materials for longer than 5 minutes. Wash out mixer four times daily if in continuous use, and after each batch if mixer is used intermittently or if a different constituent is used.

1401 AVOID CONTAMINATION of one type of material by another and by any set material.

1451 RETEMPERING: do not use mixes after initial set has taken place and do not retemper or reconstitute mixes unless permitted by the manufacturer.

1501 SCAFFOLDING: use independent scaffolding to avoid put-log holes and other breaks in coatings.

1551 CLEANLINESS: protect existing work and approaches with boards, dust sheets, etc. Droppings on finished work are to be cleaned off immediately.

1601 APPLY COATINGS firmly to achieve good adhesion and in one continuous operation between angles and joints. Coatings are not to be less than thicknesses specified, firmly bonded, of even and consistent appearance, free from rippling, hollows and ridges.

1651 FINISH SURFACES to a true plane, to correct line and level, with angles and corners to a right-angle unless otherwise specified, and with walls and reveals plumb and square.

1701 DRYING OUT: prevent rapid or localised drying out.

1751 PROTECTION: adequately protect newly applied external coatings against sun, rain and inclement weather for the first 48 hours using polythene sheet, hung clear of the face, or other approved method.

1755 MOVEMENT JOINTS: form joints in coatings to coincide with movement joints in background.

1801 MAKE GOOD defective or damaged coatings before starting decoration. Cut out and neatly make good any cracks as instructed.

## P11:2 PREPARING BACKGROUNDS

2101 ACCEPTANCE OF BACKGROUNDS: before starting preparation and applying coatings ensure that:

backgrounds are secure, adequately true and level to achieve specified tolerances, free from contamination and loose areas, reasonably dry and in a suitable condition to receive specified coatings

all cutting, chasing, fixing of concealed conduits, service outlets, fixing pads and the like and making good of the background are completed.

2151 GENERAL PREPARATION: remove efflorescence, laitance, dirt and other loose material by thoroughly dry brushing. Remove all traces of paint, grease, dirt and other materials incompatible with coating by high pressure water jet. Repeat application, if necessary, to obtain adequate suction and mechanical bond of plaster

2152 Smooth or dense concrete surfaces to receive plaster shall be mechanically hacked or sandblasted to the satisfaction of the Engineer.

2201 IN SITU CONCRETE SURFACES: scrub with water containing detergent to ensure complete removal of mould oil, surface retarders and other materials incompatible with coating. Rinse with clean water and allow to dry unless otherwise specified.

2301 KEYING/BONDING TREATMENTS: methods other than those specified may be submitted for approval.

2305 BONDING AGENT: follow the recommendations of the manufacturer.

2311 HACKING FOR KEY: roughen surfaces thoroughly and evenly by removing entire surface to a depth of 3 mm by hacking, bush hammering or abrasive blasting. Clean surfaces by washing and brushing.

2321 SPATTERDASH KEYING MIX: throw onto previously dampened surfaces to a thickness of 3 - 5 mm and leave rough. Keep damp with fine water spray or by covering with polythene until set and allow to dry out slowly and harden before applying undercoat.

2351 ADJUST SUCTION of porous or very dry masonry back-grounds by wetting immediately before applying coatings.

P11:3 FIXING METAL LATHING AND BEADS

3101 BEADS AND STOPS:

provide angle beads at all external angles except where otherwise shown

provide stop beads at all stop ends except where otherwise shown

cut neatly, form mitres at return angles and remove sharp edges, swarf and other potentially dangerous projections

fix securely, plumb, square and true to line and level; fix at not more than 600 mm centres ensuring that wings are in full contact with background; dabs if used are to be of cement and sand; fastenings are to be galvanised or stainless steel

after coatings have been applied, remove coating material while still wet from surfaces of beads and stops that are to be exposed to view.

3201 REINFORCEMENT TO SERVICE CHASES: where plastering crosses service chases and the like, cover chases with expanded metal strip fixed at not more than 600 mm centres along both edges.

3251 DISSIMILAR BACKGROUNDS FOR PLASTERING: where plastering is to be continued without break across joints between dissimilar solid backgrounds which are in

the same plane and rigidly bonded or tied together, cover joints with 150 mm wide strip of building paper to BS 1521 overlaid with 300 mm wide galvanised steel lathing fixed at not more than 600 mm centres along both edges.

3255 DISSIMILAR BACKGROUNDS FOR PLASTERING: where plaster is to be continued without break and without change of plane across the face of a column/beam/lintel which is not wider than 450 mm and is rigidly bonded or tied to the surrounding background:

cover the face of the column/beam/lintel with building paper to BS 1521 extending not less than 25 mm on to the adjacent background.

overlay with expanded steel lathing extending not less than 100 mm beyond the edges of the paper. Orientate lathing in accordance with manufacturer's recommendations and fix securely at 300 mm staggered centres along both edges.

3301 METAL LATH SUSPENDED CEILINGS:

hangers : to be straight, vertical and securely fixed at both ends to safely support the support system, lathing and coatings and to prevent subsequent movement.

framing : fix securely, rigidly and accurately to help ensure that coatings on lathing, when finished, are true to line and level, within specified tolerances and free from cracks, rippling, hollows, ridges and sudden changes of level.

lathing : stretch lathing and fix securely in accordance with manufacturer's recommendations to give a taut, firm base for plastering

fix with long way of mesh at right angles to supports and with all strands sloping in same direction

lap side edges not less than 25 mm; lap ends 50 mm at supports and 75 mm between supports; laps must not occur within 100 mm of angles or bends

tie all edges and ends together with wire ties at not more than 150 mm centres.

3401 PROTECTION: after fixing, paint staples, nail heads, cut edges and breaks in coating to steel.

P11:4 APPLYING CEMENT-SAND PLASTERING

4101 NUMBER OF COATS: apply plastering in two coats, excluding keying mix coats and dubbing out coats, finished to a thickness of 15 mm internally and 20 mm externally unless otherwise specified.

4151 ACCURACY: maximum permissible gap under a 2 m straight edge and any point on surface is to be 3 mm.

4201 DUBBING OUT:

if necessary to correct inaccuracies, dub out in thicknesses of not more than 10 mm in same mix as undercoat; total thickness of dubbing must not exceed 25 mm unless otherwise approved

in areas where thickness of dubbing will exceed 20 mm, first apply a spatterdash keying mix

comb surface of each dubbing out coat as specified, allow each coat to dry before the next is applied.

4301 UNDERCOAT:

coat is to be not less than 8 mm thick; on weak backgrounds coat is to be not less than 10 mm thick

comb surface as specified

brush down each undercoat to remove dust and loose particles and wet thoroughly before application of final coat.

4351 METAL LATHING: apply spatterdash keying mix to sufficiently coat lath and reduce interstices to the extent necessary to provide an effective key for undercoat, allow to dry out and harden for at least 24 hours before applying undercoat. Work undercoat well into interstices to obtain maximum key. Where access is possible apply undercoat to back of lath after first front undercoat has set thoroughly.

4401 PLAIN FINISH FINAL COAT: apply to uniform thickness of 6 - 10 mm and finish with a trowel or suitably faced float to give a tight, matt smooth surface. Do not apply water while working up. Do not draw excessive laitance to surface by overworking.

4501 PLASTER BACKING TO RECEIVE RIGID TILES bedded in cement and sand is to be applied in one coat of thickness not less than 15 mm and have combed surface as specified.

4551 COMBED SURFACE, where specified, is to be carried out as the coating stiffens using a suitable comb to produce evenly spaced wavy horizontal lines, approximately 20 mm apart and 5 mm deep to provide key.

4601 ROUGH CAST: throw on a plastic mix with a scoop or trowel to achieve an approved finish.

4651 DRYING: keep undercoat and final coat damp for first 3 days by covering with polythene sheet and/or spraying with water. Thereafter prevent from drying out too rapidly. Work in shade whenever possible. Allow each coat to dry out thoroughly to ensure that drying shrinkage is substantially complete before applying next coat.

# P12 SCREEDS AND TOPPINGS

## GENERAL

### P12:A SCOPE

A105 SCOPE: this Section is for the specification of floor and roof screeds and in situ floor toppings, including associated work and accessories.

### P12:B DEFINITIONS

B110 SCREED: means a layer of cement-sand or other material laid on a structural floor or roof slab to achieve the correct level, finished and prepared as a base to receive another material, typically the wearing surface.

B115 TOPPING: means a layer of cement-sand or other material laid on a structural floor slab to achieve the correct level which is itself the wearing surface. Toppings are generally laid only on floor slabs and are required to be resistant to wear and cracking.

B120 MONOLITHIC TOPPING: means a surface layer which is laid monolithically with and forming an integral part of the base slab.

### P12:D SUBMITTALS

D105 PRODUCT DATA: for each type of manufactured material and product indicated.

D110 DESIGN MIXES: for each concrete topping mix. Include alternative mix designs when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.

D115 MATERIAL TEST REPORTS: from a qualified testing agency indicating and interpreting test results for compliance of materials with requirements indicated, based on comprehensive testing of current materials:

D120 MATERIAL CERTIFICATES: signed by manufacturers certifying that each of the following materials complies with requirements:

cementitious materials and aggregates.

steel reinforcement and reinforcement accessories.

fiber reinforcement.

admixtures.

applied finish materials.

curing compounds.

D125 SHOP DRAWINGS: prepare shop drawings showing proposed patterns, movement joints and colours indicating utilities and proposed joints.

D130 INSTALLER CERTIFICATES: signed by product manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install his products.

D135 INSTALLER EXPERIENCE: list of five projects (minimum) of a similar nature carried out successfully by the installer with the same product endorsed by the manufacturer's representative.

P12:E QUALITY ASSURANCE

E105 INSTALLER QUALIFICATIONS: a qualified firm specializing in performing the work of this Section with minimum three years documented experience and that is approved, authorized, or licensed by the product manufacturer to install his product and that is eligible to receive manufacturer's warranty. Include project names and addresses, names and addresses of Consultants and owners, and other information specified

E110 COVERAGE RATE: for liquid applied coatings, calculate the quantity of material needed for the work in accordance with manufacturer's printed instructions. Submit calculations for Engineer's approval. Divide the areas to be coated and allocate the appropriate quantity of coating material for each area.

E115 READY-MIXED MANUFACTURER QUALIFICATIONS: manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.

E120 TESTING AGENCY QUALIFICATIONS: an independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated.

E125 CONCRETE TESTING SERVICE: engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixes.

E130 MOCKUPS: cast topping mockups to demonstrate typical joints, surface finish, bonding, texture, tolerances, and standard of workmanship. Confirm with the following:

build mockups approximately 10 sq. m for each pattern, if any, in the location indicated or, if not indicated, as directed by Engineer.

notify Engineer seven days in advance of dates and times when mockups will be constructed.

obtain Engineer's approval of mockups before starting construction.

if Engineer determines that mockups do not meet requirements, demolish and remove them from the site and cast others until mockups are approved.

maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.

approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## MATERIALS AND PRODUCTS

### P12:F CEMENT, AGGREGATES AND ADMIXTURES

F110 CEMENT for screed and topping mixes is to be ordinary Portland cement to BS EN 197-1 or ASTM C 150 Type 1, unless otherwise specified.

F115 PLASTICISER: to BS 4887- 1&2 water reducing admixture resulting in high quality concrete of reduced permeability with increased early strength. Use strictly as per manufacturer's recommendation.

Man: Fosroc International Ltd. [http://www.fosroc.com/GlobalHome.aspx]
Ref: Conplast SP430.

Man: BASF [http://www.chemrex.com/]
Ref: Rheomix 720

or other equal and approved.

F410 ADMIXTURES: do not use admixtures other than plasticisers and water-retaining agents without prior approval. Do not use admixtures of any type with proprietary mixes. Do not use calcium chloride or any admixtures containing calcium chloride.

F510 WATER: to be clean, free from silt, organic matter, alkali, salts and other deleterious impurities. Obtain approval of source of supply. Test to BS EN 1008.

F560 BONDING AGENT: styrene-butadiene co-polymer latex (SBR) for use as a waterproof bonding agent and admixture. When used as a bonding agent it shall have adequate pot-life for easy workability. Use strictly as per manufacturer's recommendation.

Man: Fosroc International Ltd. [http://www.fosroc.com/GlobalHome.aspx]
Ref: Nitobond SBR

Man: BASF [http://www.chemrex.com/]
Ref: Rheomix 141

or other equal and approved.

## P12:K MEMBRANES AND PROTECTIVE COVERINGS

K105 SEPARATING SHEET: polyethylene sheet 300 microns thick (1200 gauge):

Man: Visqueen Building Products. [http://www.visqueenbuilding.co.uk/]
Ref: Visqueen 300

or other equal and approved.

## P12:L LATHING AND REINFORCEMENT

L120 WELDED WIRE MESH REINFORCEMENT: electrically welded steel wire, 3 mm diameter, 150 × 150 mm mesh, galvanised after fabrication.

L180 STEEL FABRIC REINFORCEMENT: to BS 4483, Reference D49.

L185 FIBROUS REINFORCEMENT: 100 % virgin polypropylene, fibrillated fibers containing no reprocessed olefin materials and specifically manufactured to an optimum gradation for use as concrete secondary reinforcement with the following properties:

specific gravity : 0.91

tensile strength : 345 - 758 N/mm2

Proportion : not less than 0.9 kg/m3 of concrete to give the required strength.

## P12:P CEMENT BASED SCREEDS AND TOPPING MIXES

P110 CEMENT-SAND SCREED:

| | | |
|---|---|---|
| fine aggregate | : | to BS EN 12620, grading limit C or M |
| mix proportions | : | submit mix for approval to give a 28 day compressive strength of not less than 20 MPa. Minimum cement sand ratio should be not less than 1 : 4 by volume. |
| water-cement ratio | : | adjust ratio to achieve the required compressive strength. |

Where the thickness of the screed exceeds 70 mm, use fine concrete if directed. Submit mix proportions for approval.

P120 CEMENT-SAND SCREED for use in separate construction is to be not less than 50 mm thick. Add bonding agent and prime substrate surface as recommended by manufacturer.

P125 MONOLITHIC CEMENT-SAND SCREED: thin monolithic cement sand screed to be between 10 mm and 25 mm thick. Add bonding agent and prime substrate surface as recommended by manufacturer.

P515 SPRINKLE-ON FLOOR HARDENER: factory blend of selected non-metallic aggregates, Portland cement and additives, to be sprinkled on surface of green concrete (within 2 - 3 hours of casting) to give an extremely hard-wearing, skid-resistant, durable, grease and oil-resistant topping for concrete floors:

| | |
|---|---|
| 28 day compressive strength | : 70 N/mm2 |
| hardness, Moh's scale | : >7 |
| rate of application | : in accordance with manufacturer's recommendations |
| abrasion resistance | : ASTM C 944 >80% compared to controlled concrete |

Man: BASF [http://www.chemrex.com/].
Ref: Mastertop 100 (mineral aggregate) 5 kg/m2

Ref: Mastertop 300 (synthetic aggregate) 6 -7 kg/m2

Man: Fosroc International Ltd. (http://www.fosroc.com/GlobalHome.aspx)
Ref:: Nitoflor Emeritop 7 kg/m2

or other equal and approved.

P12:T EPOXY TOPPINGS

T510 EPOXY SURFACE HARDENER AND DUSTPROOFER: two component non solvented epoxy resin, colours to be selected by the Engineer from manufacturer's standard range.

Man: BASF [http://www.chemrex.com/]
Ref: Mastertop1210

or other equal and approved.

T550 POLYURETHANE HEAVY DUTY SEAMLESS FLOORING: polyurethane bonded aggregate matrix 9.5 mm thick. Flooring to be non-slip, hard wearing, resistant to corrosion, chemical spillage, trucking and steam cleaning; colours to be selected by the Engineer from manufacturer's standard range.

Man: BASF [http://www.chemrex.com/]
Ref: Ucrete HF

or other equal and approved.

T555 HEAVY DUTY SEAMLESS RESINOUS FLOORING: industrial type floor surfacing system consisting of primer; topping including: epoxy resin, hardener, colouring agent and selected fine aggregates; and finish coat or coats. Flooring to be non-slip, hard-wearing, resistant to corrosion, chemical spillage, trucking and steam cleaning. Product is to be non-toxic and suitable for food preparation areas, cold rooms and freezers (-20 deg.C). Colours to be selected by the Engineer from manufacturer's standard range.

| Property | Standard Test | Value |
|---|---|---|
| Topping thickness: | - | 6 - 8 mm |
| Compressive strength: | ASTM C 579 | 65.50 Mpa |
| Tensile strength: | ASTM C 307 | 12 Mpa |
| Flexural strength: | ASTM C 580 | 14.34 Mpa |
| Extent of burning: | ASTM D 635 | 6 mm, max. |

| | | |
|---|---|---|
| Bond strength: | - | 1.38 Mpa, 100% concrete failure, min. |
| Abrasive resistance: | ASTM C944 | 0.03 grams |
| Impact strength: | ASTM D 2794 | 13.60 N.m |
| Chemical resistance of Cured resin: | - | excellent resistance to chemicals used in food preparation areas |
| Absorption: | ASTM C 413 | < 0.15 % |
| Slip resistance: | TRRL Report | 63 (dry), 55 (wet) |

Man: RBC Industries, Inc. [http://www.rbcepoxy.com/]
Ref: Chemical Resistant Epoxy Flooring (Hef Cr)

Man: Fosroc International Ltd (http://www.fosroc.com/GlobalHome.aspx)
Ref: Nitoflor TF 5000

Man: BASF [http://www.chemrex.com/]
Ref: Mastertop 1240

or other equal and approved.

P12:V SURFACE FINISHES

V110 SLIP-RESISTANT MATERIAL: silicon carbide or aluminium oxide, graded between BS 410-1 &2 sieves 1.70 mm and 500 micro-metres.

V250 FLUID APPLIED DECK COATING: moisture-curing polyurethane elastomeric coating meeting or exceeding ASTM C 957 . It shall cure to a non-porous film that bonds tightly to the deck forming a seamless, weathertight, flexible, traffic resistant coating finished with exposed coloured aggregates.

Coatings are to be high-solids, cold liquid-applied, elastomeric membranes that produce a wearing surface for pedestrian or vehicular traffic. The coatings shall form a protective, waterproof barrier capable of bridging minor reinforced cracks and resisting various chemicals. They shall resist UV-degradation and abrasion, and exhibit slip-and-skid resistance and low-temperature flexibility, have high substrate and intercoat bond strength, and withstand pedestrian or vehicular loadings.

Vehicular Traffic Coating Grade: use heavy-duty grade at ramps and turning areas; use medium duty grade at driving aisles and parking bays, all as recommended by manufacturer.

Preparatory and Base Coats: single- or multicomponent elastomer recommended by the manufacturer of the deck coating system. Wet film thickness to be 0.65 – 0.80 mm unless otherwise recommended by manufacturer.

Intermediate Coat: single or multicomponent aromatic liquid urethane elastomer. Apply at the rate of 2.45 m2/lt for medium duty and an additional 2.45 m2/lt for heavy-duty areas unless otherwise recommended by manufacturer.

Top Coat: tough, elastic and UV resistant film comprising single- or multicomponent aliphatic liquid urethane elastomer. Color to be as selected by Engineer from manufacturer's full range. Consumption to be 2.45 m2/lt for medium duty areas to achieve wet film thickness 0.4 mm unless otherwise recommended by manufacturer.

Aggregate: uniformly graded washed silica sand of particle sizes, shape, and minimum hardness recommended in writing by traffic coating manufacturer. Spreading rate to be as recommended by manufacturer for substrate and service conditions indicated.

Traffic Marker: use same top coat material with a different color. sprinkle with glass beads:

Color: White .

Man: BASF [http://www.chemrex.com/]
Ref: Mastertop1330
Ref: Mastertop1332 for roof deck

Man: Tremco Incorporated [http://www.tremcosealants.com/commercial/]
Ref: Vulckem Traffic Deck Coating System.

Man: Carlisle Coatings & Waterproofing CCW [http://www.carlisle-ccw.com/]
Ref: CCW-5123 Vehicular Traffic Deck System.
Ref: CCW-5013 C Decorative Pedestrian Traffic Deck System.

or other equal and approved.

V270 EPOXY CONCRETE SEALER: two component solvent free epoxy sealer providing abrasion, chemical resistant, coloured, dustproof and sealed surface. When applied over concrete floors, it shall seal the surface to give:

Good chemical resistance.
Duustproofing.
Resistance to light to medium traffic
Non-slip
Resist bacteria growth
Decorative finish
Physical properties

| | | |
|---|---|---|
| Tensile Strength | BS6319-7 | 22N/mm2 |
| Flexural Strength | BS6319-3 | 60N/mm2 |
| Abrasion-Taber, 200 cycles | | 20 mgm. wt. loss |

Thickness 2 coats 250 µm

Man: Weber &Broutin
Ref: Hardack EP Coating

or other equal and approved.

P12:X ACCESSORIES

X110 DIVIDING STRIPS: 6 mm thick stainless steel alloy with polished finish, depth to give secure anchorage into mortar bedding and to finish to exact level of floor.

WORKMANSHIP

P12:1 GENERALLY

1051 STANDARDS: work in this Section is to be executed in accordance with BS 8204 and BS 8000-9, as applicable.

1055 PROPRIETARY MATERIALS: use strictly in accordance with manufacturers' recommendations.

1101 CONTROL SAMPLES: for each type of topping, complete sample areas, being part of the finished work, in approved locations, size not less than 5 m2 and obtain approval of appearance before proceeding.

1201 HOT WEATHER: take adequate precautions to protect work from premature drying out.

1301 PROTECTION: adequately protect and keep clean all completed areas. Clean off any droppings immediately. Do not heat floors or building artificially during first 4 - 6 weeks after laying and thereafter raise temperature slowly.

P12:2 PREPARING BASES

2201 CLEAN BASES thoroughly to remove concrete, mortar, plaster, dirt, dust, rust and oil.

2251 SEPARATING SHEET: ensure sheets are clean and dry. Lay single layer loose on base, lap edges 150 mm and seal with adhesive tape.

2301 UNBONDED CONSTRUCTION: lay polythene sheets and lap edges 100 mm.

2402 SEPARATE CONSTRUCTION: use if the concrete base has already set. Minimum thickness not less than 40 mm.

roughen surface by mechanical hacking

keep base slab well wetted for several hours before laying screed or topping. Remove free water then brush in cement slurry of creamy consistence. Alternatively prime as necessary and apply bonding agent to manufacturer's recommendations

lay screed or topping while bonding agent is still wet.

2403 FLOATING CONSTRUCTION: screed laid on a compressible layer such as thermal insulating boards, is to be 40 mm minimum thickness with welded wire mesh reinforcement at mid depth.

2404 MONOLITHIC CONSTRUCTION: screed laid on base concrete within 2 - 3 hours. Thickness 10 - 25 mm:

use same edge forms as for base slab

compact base slab with notched beam.

2452 STEEL FABRIC REINFORCEMENT: lay with 50 mm laps tied securely with tying wire at 300 mm centres.

2502 STEEL FABRIC REINFORCEMENT: pipes and conduits which are to be cast into screeds or toppings are to be overlaid with 450 mm wide strip of steel fabric reinforcement.

2552 FIBROUS REINFORCEMENT: for reinforced toppings, apply fibrous reinforcing as per manufacturer’s written instructions.

P12:3 LAYING CEMENT BASED SCREEDS AND TOPPINGS

3051 TESTING: carry out preliminary tests to BS 812, BS EN 1097 and BS EN 932-1, as appropriate, on natural aggregates, if instructed, and submit results for approval.

3101 STORE different aggregates separately. Store cement dry and use in order of delivery.

3201 BATCHING: mixes are to be batched by weight.

3301 MIXING:

water content of mixes is to be minimum necessary to achieve full compaction, low enough to prevent excessive mortar being brought to surface during compaction

mix materials thoroughly to uniform consistence in suitable forced action mechanical mixer, do not use free fall type (drum) mixer

use while sufficiently plastic for full compaction.

3402 JOINTS:

where not shown on the Drawings, obtain approval of location before starting work. A joint in architectural finishes is to be provided where such a joint occurs in the structural slab below

forms are to be square edged with steel top surface, securely fixed

compact thoroughly at edges to give level and closely abutted joints with no lipping.

3441 JOINTS IN BONDED TOPPINGS: bay sizes are to be not more than 15 m2, ratio of length to breadth being not more than 3 : 2 and a joint occurring over every joint in base slab.

3461 JOINTS IN UNBONDED TOPPINGS: bay sizes are to be not more than 10 m2, ratio of length to breadth being not more than 3 : 2.

3481 JOINTS IN SCREEDS: unless otherwise specified cast screeds continuously, as far as possible without joints, using 'wet screeds' between strips or bays wherever practicable.

3490 JOINTS IN SCREEDS: screeds to receive in-situ finishes are to cast in bays 15 m2, ratio of length to breadth being not more than 3 : 2. Edges are to be vertical and abut at joints.

3501 COMPACTION: dense screeds and toppings are to be fully compacted by vibrating beam or pan vibrator or where this is not practicable by hand.

3502 COMPACTION: dense screeds and toppings, if hand compacted and more than 40 mm thick are to be laid and fully compacted in two layers of identical mix, approximately equal thickness and the second layer within two hours of the first.

3541 MONOLITHIC TOPPING: compact base slab with notched beam and lay and compact topping within 3 hours of laying base (less in hot weather).thickness 10 - 25 mm.

3545 SCREED TO RECEIVE RESINOUS TOPPING: screed to be monolithic or properly bonded to concrete base using a bonding agent. Prepare base in accordance with recommendations and instructions of the topping manufacturer.

3550 BONDED SCREED: lay screed bonded to the base to a minimum thickness of 25 - 30 mm.

3555 UNBONDED SCREED: lay over a separating layer to a minimum thickness of 50 mm.

3562 FLOATING SCREED: screed over extruded polystyrene thermal insulation is to be 45 mm thick with welded wire mesh reinforcement at mid depth.

3601 TOLERANCES FOR FLOORS: sudden irregularities not permitted. Gradual irregularities expressed as maximum permissible deviation from:

3 m straight edge : +/-3 mm

1 m straight edge : +/-1 mm.

3651 TOLERANCES FOR ROOF SCREEDS: sudden irregularities not permitted. Maximum permissible deviation under a 2 m straight edge is to be +/-3 mm.

3661 LOW SPOTS: do not leave low spots between drainage outlets.

3701 SMOOTH FLOATED FINISH: use a hand float, skip float or power float to give an even surface with no ridges or steps on screeds to receive rigid tiles and the like.

3721 TROWELLED FINISH ON SCREEDS to receive thin tile and sheet floor finishes and the like:

float to an even surface with no ridges or steps

hand or power trowel to give a uniform smooth surface free from trowel marks and other blemishes and suitable to receive flooring material

adequately protect surface from construction traffic.

3731 TROWELLED FINISH ON TOPPINGS:

float to an even surface with no ridges or steps

successively hand or power trowel at intervals, applying sufficient pressure to close the surface to give a uniform smooth finish free from trowel marks and other blemishes.

3741 SLIP-RESISTANT TROWELLED FINISH for wearing surfaces:

float topping to an even surface with no ridges or steps

successively hand or power trowel at intervals, applying sufficient pressure to close the surface to give a uniform smooth finish free from trowel marks and other blemishes

apply slip-resistant material, sprinkled evenly at the rate of 1 kg/m2 and trowel into surface while topping is still plastic.

3745 SPRINKLE-ON FLOOR HARDENER for wearing surfaces:

float topping to an even surface with no ridges or steps

successively hand or power trowel at intervals, applying sufficient pressure to close the surface to give a uniform smooth finish free from trowel marks and other blemishes

apply floor hardener material, sprinkled evenly at the rate recommended by manufacturer and trowel into surface while topping is still plastic.

3751 GROOVED FINISH TO RAMPS: form series of regular 20 mm diameter grooves in surface of topping to ramps.

3781 STAIR RISERS: form with fine finish formwork, or render to give true lines and fine finish.

3791 CEMENT: do not sprinkle onto surface.

3801 CURING:

immediately after laying, protect surface of screed or topping from wind, draughts and strong sunlight
as soon as screed or topping has set, closely cover with polythene sheeting and keep in position for not less than 7 days

do not heat screeds or toppings or building artificially during first 4 - 6 weeks after laying, thereafter raise temperature slowly.

3821 FOLLOWING TRADES: take adequate precautions to prevent damage to screeds and toppings, including covering by suitable means. Make good defective work in screeds before applying finishes.

3851 ROOF SCREEDS: cover screeds during wet weather and arrange building programme to ensure that they are as dry as practicable when weathertight coverings are laid.

3901 SURFACE HARDENER: clean surfaces and apply number of coats of liquid surface hardener in accordance with manufacturer's recommendations.

3905 HARDENER TOPPING: lay monolithically with cement screed base to the thickness recommended by the manufacturer.

3910 SURFACE COATINGS:

prepare and clean surfaces in accordance with manufacturer’s recommendations

apply number of coats of liquid surface coatings in accordance with manufacturer's recommendations.

apply materials no thinner than the manufacturer's recommended spreading rate

provide the total dry film thickness of the entire system as recommended by the manufacturer, unless otherwise specified. Check wet film thickness with wet film gauge.

## P12:5 LAYING EPOXY TOPPINGS

5101 GENERALLY: epoxy toppings are to be laid on prepared bases by qualified installers approved by the topping manufacturer in accordance with the topping manufacturer's recommendations and instructions.

# P21 RIGID FLOOR AND WALL TILING AND SLABS

## GENERAL

### P21:A SCOPE

A105 SCOPE: this Section is for the specification of tiles and slabs of natural stone, terrazzo, concrete, and ceramics, in coverings to floors, walls, roofs and soffits, including associated work and accessories.

This Section includes external or internal natural stone tiles and slabs supported and fixed to a solid background by use of mortar bedding or adhesive, with or without plain wire ties.

### P21:B DEFINITIONS:

B105 NON-VITREOUS TILE: a tile with water absorption more than 7% (E > 7%).

B115 SEMI-VITREOUS TILE: a tile with water absorption more than 3% but less than 7% (3% < E < 7%).

B120 VITRIFIED TILES (VITREOUS TILE): a tile with water absorption less than 3% (E < 3%).

B125 FULLY VITRIFIED (FULL BODY OR PORCELEIN TILE) tiles with water absorption generally less than 0.5% (E < 0.5%) and have abrasive hardness rating of 100 (ASTM C 501).

### P21:D SUBMITTALS

D105 SHOP DRAWINGS: submit shop drawings showing tile and slab installations, including but not necessarily limited to the following:

plans and elevations showing locations, layouts and patterns

locations, widths and details of expansion, contraction, control and isolation joints, and division strips in tile/slab substrates and finished tile/slab surfaces

locations and details of waterproofing underlayments.

D110 SAMPLES: before placing orders submit for approval and selection of colours, finishes and textures, representative samples of each type and composition of tile and slab indicated, together with associated trims and accessories. Ensure that delivered materials match approved samples.

D115 TESTING: for each type of natural stone proposed to be used, submit supplier's certified results for following tests:

weight per unit of volume
absorption coefficient
compression breaking load
compression breaking load after freezing
ultimate tensile strength.

D120 CONTROL SAMPLES: for each type of tile and slab covering, complete sample areas, being part of finished work, in approved locations, sizes not less than: 5 m2 for wall areas and 10 m2 for floor areas, including division strips where applicable. Obtain approval of appearance before proceeding.

For fully vitrified tiles with low water absorption, make trial samples with the type of bedding selected and test for proper adhesion.

P21:E WARRANTY

E105 GENERAL WARRANTY: The special warranty specified in this Article shall not deprive Employer of other rights Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other warranties made by Contractor under requirements of the Contract Documents.

E101 SPECIAL WARRANTY: Provide written guarantee in a form acceptable to the Engineer, signed by Tile manufacturer, installer and Contractor, undertaking to repair or replace, without limitations, all or any part of ceramic tiling which fails or becomes defective in materials or workmanship within specified warranty period. Failure includes, but is not limited to:

Will not fade from sunlight or artificial light.
will not chip, crack or show crazing marks
Will not show wear-through (loss of glaze, where the body of the tile shows through, due to normal use).
Will not contain manufacturing defects.

Warranty Period: twenty (20) years from date of Substantial Completion.

MATERIALS AND PRODUCTS

P21:K MEMBRANES AND PROTECTIVE COVERINGS

K105 SEPARATING SHEET: polyethylene sheet 300 microns thick (1200 gauge):

Man: Visqueen Building Products [http://www.visqueenbuilding.co.uk/].
Ref: Visqueen 300

or other equal and approved.

P21:L LATHING AND REINFORCEMENT

L120 WELDED WIRE MESH REINFORCEMENT: electrically welded steel wire, 3 mm diameter, 50 x 50 mm mesh, galvanised after fabrication.

P21:S TILES AND SLABS

S105 NATURAL STONE SLABS AND FITTINGS GENERALLY: to be first quality stone, each type obtained from one strata, from one quarry and delivered to the site in one shipment. Slabs are to be hard and free from cracks and other defects to surfaces and edges which may impair structural integrity, function or appearance. Slabs are to be cut square and true with clean edges and, uniform in shape and thickness. Length and width dimensions of individual slabs are to be within +/-1 mm and thickness within 3 mm from those specified or shown on the Drawings.

S110 LIMESTONE SLABS AND FITTINGS: approved natural limestone cut slabs to ASTM C568 with finish indicated on the drawings, obtained from one strata of one quarry, free from faults and to the shapes, sizes and patterns shown on drawings. Limestone slabs to have the following minimum properties:

Density: 2560 kg/$m^3$
Compression strength: 55MPa
Water absorption: 3%
Modulus of rupture: 6.9 MPa.
Abrasion resistance C241, Ha: 10

S125 MARBLE SLABS AND FITTINGS: approved natural marble slabs to ASTM C503 with finish indicated on the Drawings, obtained from one strata of one quarry, free from faults and to the shaped, sizes, and patterns shown on the Drawings. Marble slabs to have the following minimum properties:

| | |
|---|---|
| Density: | 2800 kg/m3 |
| Compression strength: | 52 MPa |
| Water absorption: | 0.2 % |
| Modulous of rupture: | 7 MPa. |
| Abrasion resistance C241, Ha: | 10 |

S145 MARBLE THRESHOLDS AND SADDLES: best quality Italian Carrara marble with polished finish.

S155 MARBLE COVERINGS to counters, vanitory units and the like, where shown on the Drawings, are to be best quality marble with polished finish.

S160 MARBLE STAIR TREADS AND RISERS: best quality marble with polished finish.

S165 MARBLE URINAL PARTITIONS: best quality Italian Carrara marble with polished finish.

S205 TERRAZZO TILES AND FITTINGS: to BS EN 13748 1, 2, mechanically vibrated in the moulds, hydraulically pressed by 14 - 18 N/mm2 (depending on size of tile) and steam cured with 100% humidity for 14 hours at 65 deg.C, comprising:

marble aggregate

size of aggregate up to 12 mm

white cement

pigment to BS EN 12878, colour

Water absorption for any single test when tested in accordance with BS EN 13748-1, 2 shall be not more than 0.4 g/m2 for tile face and 8 % for the whole tile unit.

Transverse strength shall not be less than 3 N/mm2 for any single result.

The facing layer shall be such as to provide a minimum wearing thickness of not less than 8 mm after grinding and shall include 70% coverage of the tile face with marble aggregate.

The base layer shall consist of a 1: 3 mix of cement-aggregate (by weight). Aggregates shall conform to BS EN 12620.

Terrazzo tiles and fittings are to have a fine grit finish as specified, to sizes as shown on Drawings, colours to be selected by the Engineer.

S255 TERRAZZO SLABS AND FITTINGS: to BS EN 13748-1, 2, Type A, cast in suitable moulds, pressed, well compacted and steam cured with 100% humidity for 14 hours at 65 deg.C, comprising:

marble aggregate

size of aggregate up to 12 mm

whitecement

pigment to BS EN 12878

The facing layer shall be such as to provide a minimum wearing thickness of not less than 12 mm after grinding.

Terrazzo tiles and fittings are to have a fine grit finish as specified, to sizes as shown on Drawings, colours to be selected by the Engineer.

S305 CONCRETE FLOOR TILES AND FITTINGS: to BS EN 1339, precast, hydraulically pressed concrete tiles and fittings, to sizes as shown on Drawings, colour natural or to be selected by the Engineer.

S355 CONCRETE PAVING SLABS AND FITTINGS: to BS 7263-1, precast, hydraulically pressed concrete paving slabs, to sizes as shown on Drawings, colour natural or to be selected by the Engineer.

S505 CERAMIC FLOOR TILES AND FITTINGS: to BS EN 14411, with water absorption E < 3%. Tiles are to be vitrified unglazed, acid-resistingwith non-slip finish and to sizes as shown on Drawings. Submit samples and catalogues for selection of colours by the Engineer from manufacturer's standard range.

Man: RAK Ceramics
Man: Villeroy & Boch [http://www.villeroy-boch.com/]
Man: Agrob Buchtal Ceramics [http://www.agrob-buchtal.de/dscb_abo_site/en/index.html]
Man: Marazzi [http://www.marazzi.it/]

or other equal and approved.

S506 PORCELAIN FLOOR TILES AND FITTINGS: to BS EN 14411, with water absorption e<0.5 %. Tiles are to be fully vitrified unglazedacid-resisting with non-slip finish and to sizes as shown on Drawings. Submit samples and catalogues for selection of colours by the Engineer from manufacturer's standard range.

Man: RAK Ceramics
Man: Villeroy & Boch [http://www.villeroy-boch.com/]
Man: Casalgrande Padana [http://www.casalgrandepadana.it/]

Man: Marazzi [http://www.marazzi.it/]

or other equal and approved.

S517 PORCELAIN STAIR TILES AND FITTINGS: to BS EN 14411, with water absorption e<0.5 %. Tiles are to be fully vitrified unglazed acid-resisting with non-slip finish with 4 grooves in the front of the tread area running transverse to the stair direction and to sizes as shown on Drawings. Submit samples and catalogues for selection of colours by the Engineer from manufacturer's standard range.

Man: RAK Ceramics
Man: Villeroy & Boch [http://www.villeroy-boch.com/]
Man: Casalgrande Padana [http://www.casalgrandepadana.it/]
Man: Marazzi [http://www.marazzi.it/]

or other equal and approved.

S555 CERAMIC WALL TILES: to BS EN 14411, with water absorption 3% < E ≤ 6%. Tiles are to be vitrified gloss glazed with cushion edges and spacer lugs and to sizes as shown on Drawings. Submit samples and catalogues for selection of colours by the Engineer from manufacturer's standard range.

Man: RAK Ceramics
Man: Villeroy & Boch [http://www.villeroy-boch.com/]
Man: Agrop Buchtal Ceramics
Man: Marazzi [http://www.marazzi.it/]

or other equal and approved.

S556 PORCELAIN WALL TILES AND FITTINGS: to BSEN 14411, with water absorption e<0.5 %. Tiles are to be fully vitrified glazed and to sizes as shown on Drawings. Submit samples and catalogues for selection of colours by the Engineer from manufacturer's standard range.

Man: RAK Ceramics
Man: Villeroy & Boch [http://www.villeroy-boch.com/]
Man: Casalgrande Padana [http://www.casalgrandepadana.it/]
Man: Marazzi [http://www.marazzi.it/]

or other equal and approved.

S605 MOSAICS: to BS EN 14411 unglazed with water absorption E<0.1%. Shape and size shall be as indicated on drawings.

Man: RAK Ceramics

or other equal and approved.

P21:X ACCESSORIES

X310 DIVIDING STRIPS: 6 mm thick with polished finish, depth to give secure anchorage into mortar bedding and to finish to exact level of floor:

galvanised steel bottom-section material with stainless steel top-section material, for interior applications.

X410 STAIR NOSINGS: nosing base to be aluminium alloy extruded section type 6063-T5. Anti-slip fillers shall contain not less than 65% virgin grain aluminium oxide/silicon carbide abrasive. Binders to be a fully cured resilient type epoxy; epoxy binder to filler ratio to be 13% minimum for improved cleaning.

Man: Gradus Ltd. [http://www.gradusworld.com/]
Man: Schlüter Systems [http://www.schluter.com/]
Man: The Safety Tread Ltd. [http://www.safetytread.co.uk]
Man: American Safety Tread [http://americansafetytread.com]

or other equal and approved.

X415 STAIR NOSINGS: anti-slip inserts made from not less than 65% virgin grain aluminium oxide/silicon carbide abrasive. Binder is to be a fully cured resilient type epoxy; epoxy binder to filler ratio to be 13% minimum for improved cleaning. Insert shall be pressure-bonded into stair tread.

X450 TERRAZZO SEALER: slip and stain-resistant, penetrating-type sealer that is chemically neutral with pH factor between 7 and 12, does not affect colour or physical properties of terrazzo type indicated and is recommended for this particular purpose and use by the sealer manufacturer.

Man: Building Adhesives Ltd (BAL)
Ref: BAL Impregnating Sealer

or other equal and approved.

P21:Y BEDDING AND JOINTING MATERIALS

Y105 CEMENT-SAND MORTAR for bedding tiles and slabs is to be to the requirements of Section G21 of the Specification and unless otherwise specified, is to comprise:

ordinary Portland cement to BS EN 197-1, except for marble types that may stain as a consequence of use, substitute white Portland cement to BS EN 197-1

sand for walls to BS EN13139

sand for floors to BS EN 12620, Table 5, grading limit M, but where fine sand is specified grading limit F

Submit mix for approval to give a 28 day compressive strength of not less than 5 MPa. Minimum cement sand ratio should be not less than 1:3-4 by volume.

Y210 ADHESIVE BEDDING FOR WALL TILING AND MOSAICS: factory premixed latex-Portland cement thin bed adhesive to ANSI A118.4 or BS BS EN 12004, incorporating SBR latex.

| | | |
|---|---|---|
| Wet density | ASTM C905 | 1634 KG/M3 |
| Open time | ANSI A118.4 | 50 minutes |
| Shear bond strength | ANSI A118.4/ F5.2.4 | 3.5 MPa |
| Compressive strength | ANSI A118.4/ F.6.1 | 34.5 MPa |
| Hardness | ASTM D2240 | 50-60 |

Man: American Olean Co. Inc.

Man: Ardex Ltd

Man: Building Adhesives Ltd (BAL)
Ref: BAL White Star

Man: Fosroc International

Man: Laticrete
Ref: Laticrete 4237 and Laticrete 211 filler powder

or other equal and approved.

Y505 CEMENT-SAND GROUTING MIX for tiles and slabs is to be to the requirements of Section G21 of the Specification and unless otherwise specified, is to comprise:

white Portland cement to BS EN 197-1

sand to BS 1199, Table 1/ BS EN13139

mix proportions: 1: 2 or 3 parts cement-sand.

Y512 GROUT FOR MARBLE AND TERRAZZO tiles and slabs is to be proprietary type mixed in accordance with manufacturer's instructions. Submit samples for selection of colours by the Engineer from manufacturer's standard range.

Man: Building Adhesives Limited (BAL)
Ref: Bal-Marble and Terrazzo Grout

Man: Laticrete
Ref: Laticrete 600 series for non-sanded grouts, for joints < 3 mm wide

Man: American Olean Co. Inc.

or other equal and approved.

Y514 EPOXY GROUT for tiles and slabs is to be proprietary type non-toxic chemically resistant two-pack epoxy grout mixed in accordance with manufacturer's instructions. Submit samples for selection of colours by the Engineer from manufacturer's standard range.

Man: Building Adhesives Limited (BAL)
Ref: Bal-Easypoxy Grout (walls)
Ref: Bal-Floor Epoxy Grout (floors)
Ref: Bal-Floor Epoxy Grout LV (floors)

Man: Laticrete
Ref: Latapoxy SP 100

Man: American Olean Co. Inc.

or other equal and approved.

## WORKMANSHIP

### P21:1 GENERALLY

1051 STANDARDS: work in this Section is to be executed in accordance with BS 5385-1 >5 and BS 8000-11.1, 11.2, as applicable.

1201 QUALITY OF WORK:

operatives must be appropriately skilled and experienced in fixing and laying the specified finishes

carry out work and use materials in strict accordance with manufacturers' recommendations and instructions.

1205 NATURAL STONE SLABS: some limestone, marble or Granite slabs may discolour when bedded in cement mortar.

For light coloured marbles or limestones, try to bed in white Portland cement mortar. Make trial samples and get the approval of Engineer.

For granites, bed in factory premixed latex-Portland cement thin bed adhesive incorporating SBR latex.

Alternatively, for granites, coat back of tiles with adhesive and scratch before setting to provide key. Bed in factory premixed latex-Portland mortar.

1501 TOLERANCES FOR FLOOR FINISH: sudden irregularities not permitted. Gradual irregularities expressed as maximum permissible deviation from:

3 m straight edge : +/-3 mm

1 m straight edge : +/-1 mm.

1521 TOLERANCES FOR ROOF FINISH: sudden irregularities not permitted. Maximum permissible deviation under a 2 m straight edge is to be +/-3 mm.

1551 TOLERANCES FOR WALL FINISH: sudden irregularities not permitted. Maximum permissible deviation under a 2 m straight edge is to be +/-1.5 mm.

1601 SETTING OUT:

joints are to be true to line, continuous and without steps

joints in walls are to be truly horizontal, vertical and in alignment around corners

joints in floors and roofs are to be parallel to main axis of space

cut tiles and slabs are to be kept to minimum, as large as possible and in unobtrusive locations

joints in wall tiles and in floor tiles are to be aligned

where positions of movements joints and dividing strips are not shown they are to be agreed with the Engineer.

1651 JOINTS WIDTHS, unless otherwise specified, are to be as follows:

| | | |
|---|---|---|
| polished natural stone floor slabs | : | 2 mm |
| other floor slabs, and ceramic floor tiles | : | 5 mm |
| other floor tiles and roof tiles | : | 3 mm |
| wall tiles | : | 3 mm for tiles without spacer lugs |

1801 HOT WEATHER: take adequate precautions to protect work from premature drying out.
1851 WELDED WIRE MESH REINFORCEMENT: mortar bedding over compressible bases such as extruded polystyrene in inverted roofing are to be reinforced with welded wire mesh.

## P21:2 PREPARING BACKGROUNDS AND BASES

2101 GENERALLY: ensure that backgrounds and bases are suitably level and true, sound, free from grease, oil, dirt and other contaminants and sufficiently dry when tiles and slabs are fixed.

2151. PROVIDE SUBSTRATES for wall or floor tile installed with dry-set or latex-portland cement mortars that comply with flatness tolerances specified in referenced ANSI A108 series of tile installation standards for installations indicated.

2161 FOR WALL PREPARATION: use cement plaster, with wire mesh reinforcement where necessary, and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions.

2171 FOR WALL PREPARATION: use trowelable levelling and patching compounds per tile-setting material manufacturer's written instructions to fill cracks, holes, and depressions. Remove protrusions, bumps, and ridges by sanding or grinding.

2201 DRYING OUT: before fixing tiles and slabs ensure that backgrounds and bases have been allowed to dry out by exposure to air for not less than:

5 weeks for concrete walls and slabs

2 weeks for block walling, plaster and screed

3 weeks for rendering.

2301 FLATNESS: before fixing tiles and slabs ensure that backgrounds and bases are sufficiently flat to permit specified flatness of finished surfaces.

## P21:3 BEDDING MATERIALS

3101 MORTAR FOR BEDDING:

batch by volume; specified proportions are for dry sand, allow for bulking if damp

mix materials thoroughly to uniform consistence in suitable forced action mechanical mixer; do not use free fall type (tilting drum) mixer; use minimum amount of water necessary to give required workability

use mortar within 2 hours of mixing at normal temperatures; do not use after initial set has taken place and do not retemper.

3202 ADHESIVE FOR BEDDING: use SBR or acrylic latex emulsions as directed by manufacturer

## P21:4 FIXING WALL TILES

4051 CEMENT-SAND FIXING FOR WALL TILES AND SLABS:

dampen background and apply float coat of cement-sand mortar bedding to an even thickness of not more than 10 mm; finish with wood float and allow to stiffen slightly before applying tiles and slabs

without delay, and using cement-fine sand mortar, fill any keys and apply 2 mm thick coat to entire back of each tile and slab; press tiles and slabs onto float coat and tap firmly into position.

4101 ADHESIVE FIXING FOR WALL TILES: unless otherwise recommended by manufacturer, apply floated coat of adhesive to dry plastered background and comb surface with recommended solid bed trowel. Fill any keys and apply thin even coat of adhesive over entire back of each tile. Press tiles onto bedding with twisting/sliding action to give finished bed thickness within range recommended by manufacturer.

4201 ADHESIVE FIXING FOR MOSAIC:

apply 3 mm floated coat of adhesive to dry plastered background and comb surface with recommended solid bed trowel

pre-grout mosaic sheets and remove surplus before fixing; hang mosaic sheets in horizontal rows working downwards, with vertical joints staggered; ensure that width, plane and alignment of joints between sheets matches joints between mosaic tiles; grout joints between sheets before removing paper face

before adhesive hardens completely, wet and carefully remove paper face; complete grouting and remove glue from face of mosaic by washing.

4501 SKIRTINGS: bed coved skirtings solid to walls before laying floor tiles and slabs. Bed sit-on skirtings solid to walls after laying floor tiles and slabs. Ensure joints in skirtings match and align with joints in floor tiling and slabs.

P21:5 FIXING FLOOR TILES:

5051 SEMI DRY MIX METHOD: suitable for ceramic, mosaics, limestone, concrete and terrazzo tiles and slabs:

if base is dry and porous, dampen as necessary to reduce absorption

spread, thoroughly compact and level semi-dry cement-sand mortar 1: 4 of a crumbly consistency not less than 25 mm thick. Lay on concrete base without sand bed.

in beddings exceeding 50 mm thick, use semi-dry concrete mix with 10 mm maximum size aggregate in the proportion of 2: 3: 6 of cement-dry fine aggregate-dry coarse aggregate (by weight)

overlay compacted bedding with cement-sand slurry 1: 1 (by volume), with sufficient water to make it slightly fluid and spread with trowel to 3 mm thickness

lay tiles preferably dry. Dip rather porous tiles in water and allow to drain

slurry backs of concrete and terrazzo tiles before laying

lay tiles without delay and within two hours of laying bed. Firmly beat down into bedding to form even surface.

5052 General: Install tile to comply with requirements in the Ceramic Tile Floor Installation Schedule, including those referencing TCA installation methods and ANSI A108 series of tile installation standards.

Immediately prior to applying the mortar bed, evenly dampen preceding surface coat or the clean concrete block surface with water as required.

Dampen clean, properly prepared concrete surface with water immediately prior to placing the bonded mortar bed. Concrete surface to be completely free of standing water.

Before placing mortar bed spread a very thin continuous coating of pure Portland cement on the concrete and wet it. Broom the pure Portland cement slurry or the wetted Portland cement dust to completely coat the concrete surface with a thin and uniform coating.

Immediately apply mortar bed over the pure cement coating. Firmly tamp and screed mortar bed. Mortar bed thickness shall be a nominal 32mm.

Soak tile in clean water for at least 1/2 hour and drain excess water before setting. Immerse each tile completely during the soaking period. Resoak and drain tiles that exhibit drying along the edges before setting. Free moisture shall not remain on the backs of the tile when they are being set.

Back butter each tile with bond coat prior to firmly pressing it into position and beat-in.

Set tile firmly on the mortar bed. Lugs on tile determine the joint width between tiles. Spacers, string or rope shall be used to space tile that have no lugs. Bring all surfaces to a true plane at the proper position or elevation. Thoroughly beat-in all tile while the mortar bed is still workable. The beat-in shall fill the entire space between ribs of tile with mortar.

5053 CERAMIC, MOSAICS, CONCRETE AND TERRAZZO TILES: bed in cement-:sand mortar 1: 3 - 4 (by volume) of stiff plastic consistency over a separating layer. Bed thickness to be 15 - 20 mm.

5201 NATURAL STONE FLOOR TILES AND SLABS: bed in cement-sand mortar 1: 3 - 4 (by volume). Bed thickness to be 15 - 25mm.

5251 ADHESIVE FIXING FOR FLOOR TILES: apply floated coat of adhesive to dry base and comb surface with recommended solid bed trowel. Apply adhesive to backs of tiles as necessary to fill any depressions or keys. Press tiles firmly into position to give finished bed thickness within range recommended by manufacturer.

P21:6 FIXING TRIMS AND SUNDRY ITEMS

6101 STAIR NOSINGS AND TRIMS: fix securely and level with neatly mitred joints, adjusting to suit thickness of covering. Fully bed in gap-filling adhesive and screw fix as recommended by nosing manufacturer.

P21:7 GROUTING AND COMPLETION

7101 MIX CEMENT GROUTS thoroughly with minimum of clean water to give required workability.

7105 MIX PROPRIETARY GROUTS as recommended by their manufacturer.

7151 GROUTING: do not grout tiles or slabs until their bedding has set sufficiently to resist displacement and following adhesive and grout manufacturers' recommendations.

7201 GROUTING: work grout well into joints so they are completely filled. Finish flush and thoroughly clean off surplus grout as work proceeds.

7301 FINE GRIT FINISH TO MARBLE AND TERRAZZO TILING AND SLABS:

surface grinding and polishing should not commence sooner than 3 days after grouting, or until the grouted joints are thoroughly hardened and cured

mechanically grind surface using coarse grit stones and water

carry out a second grinding using finishing grade stones

thoroughly clean and wash floor to remove grinding residue and dust

fill holes and depressions in surface with matching grout well pressed into surface and allow to harden

mechanically polish surface with fine grit stones and water to a mirror polish, wash surface clean and keep free from traffic for at least 2 days

dry grinding will be permitted only where it is not practicable to use the wet process.

7351 SEALING TERRAZZO SURFACES: apply sealer according to sealer manufacturer's written instructions.

7501 PROTECTION: adequately protect and keep clean all completed areas. Clean off any droppings immediately.

7551 TILING IN SHOWERS and other ‘wet areas’ is to be kept dry and not brought into service for at least 3 weeks after grouting.

# R11 GENERAL GLAZING

## GENERAL

### R11:A SCOPE

A105 SCOPE: this Section is for the specification of glass, including special glasses, insulating glazing units and custom mirrors.

### R11:C SUBMITTALS

C105 GENERAL: submit the following:

Product data for each glass product and glazing material indicated.

Samples for verification and approval:

300 mm square samples of each type of glass indicated except for clear monolithic glass products

300 mm long samples of each type of sealant or gasket exposed to view and in each colour required, except black. Install sealant or gasket sample between two strips of material representative in colour of the adjoining framing system.

Product certificates signed by glazing materials manufacturers certifying that their products comply with specified requirements. Separate certifications are not required for glazing materials bearing manufacturer's permanent labels designating type and thickness of glass, provided labels represent a quality control programme of a recognised certification agency or independent testing agency acceptable to the Engineer.

Compatibility and adhesion test reports from sealant manufacturer indicating that glazing materials were tested for compatibility and adhesion with glazing sealants. Include sealant manufacturer's interpretation of test results relative to sealant performance and recommendations for primers and substrate preparation needed for adhesion.

Compatibility test report from manufacturer of insulating glass edge sealant indicating that glass edge sealants were tested for compatibility with other glazing materials including sealants, glazing tape, gaskets, setting blocks, and edge blocks.

Product test reports for each type of glazing sealant and gasket indicated, evidencing compliance with requirements specified.

Maintenance data for glass and other glazing materials to be incorporated into the Operating and Maintenance Manual.

Glass manufacturers' guarantees in a form acceptable to the Engineer, undertaking to replace free of charge any and all glass panels which, within 5 years of the date of substantial completion, are the subject of spontaneous breakage due to the presence of nickel sulphide.

C115 LOADING REQUIREMENTS: Glass thicknesses indicated are minimums and are for detailing only. Confirm glass thicknesses by analyzing Project loads and in-service conditions. Provide glass lites for various size openings in nominal thicknesses indicated, but not less than thicknesses and in strengths (annealed or heat treated) required to meet or exceed the following criteria:

Glass Thicknesses: Select minimum glass thicknesses to comply with design wind loads applicable to Project from basic wind speed indicated in meters per second at 10 ms above grade, according to applicable code based on mean roof heights

Safety: verify that the specified glass can withstand the actual loading requirements in respect of heat treatment and safety.

R11:D QUALITY ASSURANCE

D105 GLAZING PUBLICATIONS: comply with published recommendations of glass product manufacturers and the glazing organisations, except where more stringent requirements are indicated.

- BS 952 and relevant parts of:
  - BS EN 572 for basic soda lime silicate glass.
  - BS EN 1096 for coated glass.
  - BS EN 1748-1 for borosilicate glass.
  - BS EN 1748-2 for ceramic glass.
  - BS EN 1863 for heat strengthened soda lime silicate glass.
  - BS EN 12150 for thermally toughened soda lime silicate safety glass.
  - BS EN 12337 for chemically strengthened soda lime silicate glass.
  - BS EN 13024 for thermally toughened borosilicate safety glass.
  - BS EN ISO 12543 for laminated glass and laminated safety glass.

D110 SAFETY GLASS: products complying with BS EN ISO 12543 for laminated glass and BS EN 12150 and BS EN 1863 for heat treated glass. Subject to compliance with requirements, provide safety glass permanently marked with certification label of Safety Glazing Certification Council (SGCC) or other certification agency acceptable to the Engineer.

D115 INSULATING GLASS: provide insulating glass units permanently marked either on spacers or at least one component light of units with appropriate certification label of inspecting and testing agency or other certification agency acceptable to the Engineer.

D120 GLAZIER QUALIFICATIONS: engage an experienced glazier who has completed glazing similar in material, design, and extent to that indicated for project with a record of successful in-service performance.

D125 SINGLE-SOURCE RESPONSIBILITY: obtain glass from one source for each product indicated below:

primary glass of each (ASTM C 1036) type and class indicated

heat-treated glass of each (ASTM C 1048) condition indicated

laminated glass of each (ASTM C 1172) kind indicated

insulating glass of each construction indicated.

D130 SINGLE-SOURCE RESPONSIBILITY: obtain glazing accessories from one source for each product and installation method indicated.

D135 COLOUR OF GLASS: colour variation shall not be accepted. Light transmission shall not vary by more than 0.05%.

D140 GLASS SUPPLIES: all glass supplies shall be cut from the same batch.

D145 HEAT TREATED GLASS: heat treated glass shall be entirely free from nickel sulphide. Provide certificate from supplier that all heat-treated glass units have successfully passed heat-soak test.

D146 FULL HEAT-SOAK TEST: Provide certificate from supplier that all heat-treated glass units have successfully passed full heat-soak test to an approved international specifications such as EN 14179 or DIN 18516 which ever is the more stringent

D150 SITE-CONSTRUCTED MOCK-UPS: prior to glazing, erect mock-ups for each glass product indicated below to verify selections made under sample submittals and to demonstrate aesthetic effects and quality of materials and execution. Build mock-ups to comply with the following requirements, using materials indicated for the finished work:

Glass products: erect mock-ups with the following kinds of glass to match glazing systems required for project, including typical light size, framing systems, and glazing methods in order to demonstrate the proposed range of aesthetic effects and workmanship:

heat-strengthened coated glass
fully tempered glass
spandrel glass
laminated glass
coated insulating glass.

Erect mock-ups on site in locations and of size indicated or, if not indicated, as directed by Engineer.

Notify Engineer one week in advance of the dates and times when mock-ups will be erected.

Obtain Engineer's approval of mock-ups before proceeding.

Retain and maintain mock-ups during construction in undisturbed condition as a standard for judging finished work. Approved mock-ups in undisturbed condition at time of substantial completion may become part of finished work.

D155 SEALANT COMPATIBILITY AND ADHESION TESTING: submit to sealant manufacturers, samples of each glass, gasket, glazing accessory, and glass-framing member that will contact or affect glazing sealants, for compatibility and adhesion testing as indicated below:

use test methods standard with sealant manufacturer to determine if priming and other specific preparation techniques are required for rapid, optimum glazing sealants adhesion to glass and glazing channel substrates

perform tests under normal environmental conditions during installation

submit not less than nine pieces of each type and finish of glass-framing members and each type, class, kind, condition, and form of glass (monolithic, laminated, insulating units) for adhesion testing, as well as one sample of each glazing accessory (gaskets, setting blocks and spacers) for compatibility testing

schedule sufficient time to test and analyse results to prevent delay in the work

investigate materials failing compatibility or adhesion tests and get sealant manufacturer's written recommendations for corrective measures, including using special primers

except for Structural-Sealant-Glazing, testing may not be required when glazing sealant manufacturer can submit required preparation data that is

acceptable to Engineer and is based on previous testing of current sealant products for adhesion to and compatibility with submitted glazing materials.

MATERIALS AND PRODUCTS

R11:M GLASS MANUFACTURERS AND PROCESSORS

A. GLASS MANUFACTURERS:

Saint Gobain
Pilkington
PPG Industries

or other equal and approved.

B. GLASS COATERS:

Emirates Glass
Saudi American Glass

or other equal and approved.

R11:R GLASS

R11:R1 SINGLE GLASS

R110 GLASS GENERALLY: to BS 952-1 and BS 952-2, clean cut without edge faults and free from bubbles, inclusions, cracks, rippling, dimples and other defects.

R115 FLOAT GLASS: to BS 952-1 and BS 952-2.

R116 HEAT-TREATED FLOAT GLASS: to ASTM C 1048; Type I; Quality-Q3; (clear) unless otherwise indicated; of kind and condition indicated.

R125 TRANSLUCENT GLASS: to BS 952-1 and BS 952-2 with fine texture and high obscurity.

R150 SPANDREL GLASS: Low-E coated tinted heat-strengthened spandrel glass, with opacifier on coated second surface.

Outer Pane:

Kind: : Kind HS (heat strengthened)
Glass thickness : 6mm
Tint colour : Bronze
Coating type : Low-E.
Coating location :2nd surface.
Inner Pane: 50mm extruded polystyrene insulation with aluminium foil backing.

R180 FIRE RESISTANT GLASS: Proprietary fire resistant glass fully heat-treated

Man: Pilkington glass Ltd.
Ref: Fire resistant glass

Man: AGC
Ref: Fire resistant glass

Man: Saint Gobain
Ref: Pyroswiss Plus (extra clear) E90, 6.0 mm thick

or other equal and approved.

R185 MIRROR GLASS: float glass with silvering, electroplated copper and protective organic coatings. Silvered to give maximum reflection, free from tarnish, discolouration, scratches and other defects visible in the designed viewing conditions. 6 mm nominal thickness and with polished bevelled edges, unless otherwise specified or indicated.

R11:R2 LAMINATED GLASS

R210 LAMINATED SAFETY GLASS: comply with BS 952-1 and BS 952-2 impact performance to BS 6206, Class A and and BS EN ISO 12543for kinds of laminated glass indicated and other requirements specified or otherwise indicated. Refer to primary and heat-treated glass requirements relating to properties of glass products comprising laminated glass products.

Interlayer material to be Polyvinyl butyral sheets, clear, and of thickness indicated with a proven record of no tendency to bubble, discolour, or lose physical and mechanical properties after laminating glass lights and installation.

Fabricate laminated glass with polyvinyl butyral interlayer in autoclave with heat plus pressure to produce glass free of foreign substances and air or glass pockets.

1. Glass:
   a. Clear inner light: Class 1 (clear) float glass, with a thickness of 3mm.
   b. Clear outer light: Class 1 (clear) float glass with a thickness of 3mm.

3. Kind of laminated glass per ASTM C 1172: kind LA. Total thickness 6mm.

4. Colour of plastic interlayer: clear.
5. Interlayer: 2 number PVB sheets, clear, 0.76 mm thick.

R11:R3 INSULATING GLASS

R305 INSULATING GLASS UNITS: to BS 5713, factory made, hermetically sealed, double glazed units. Clear tempered inner lite and Low-E tempered outer lite.

Type: bronze –Tinted, Tempered, Insulating glass

Specification:

1.Outdoor lite: Bronze tinted fully tempered
a-Thickness: 6mm

2.Interspace content :Air (12mm)

3.Indoor Lite: Clear fully tempered float glass
a-Thickness: 6mm

Application: External windows & skylight above green patios

U-value = 2.8 $W/m^2/K$ ; Shading coefficient = 0.58; Light transmittance = 45 % ; solar heat gain coefficient = 0.50

R11:S PLASTICS

S206 PLASTICS GLAZING SHEET: Translucent polycarbonate sheet; ASTM C 1349, Appendix X1, Type I (standard, UV stabilized), with a satin finish for smooth appearance.

Nominal Thickness: not less than 8mm.
Colour and Pattern: as indicated.
Combustibility Class: CC1.
Flame-Spread Index: 25 or less.
Provide safety glazing labelling.
Transmission factor of polycarbonate panel: as indicated.

R11:X ACCESSORIES AND COMPOUNDS

X110 GLAZING COMPOUNDS, TAPES, STRIPS, GASKETS AND SEALANTS unless otherwise specified are to be types recommended for particular purpose by glass and frame surround manufacturers and, are to be obtained from approved manufacturers.

X210 RUBBER GASKETS: to BS 4255-1, fully compatible with glazing sealants.

X310 SILICONE SEALANT: to BS 5889, Type A, colour to be selected by the Engineer from manufacturer's standard range.

X620 CLIPS FOR FIXING MIRRORS: brass nickel plated fixed bottom clips and adjustable top clips with resilient packing.

## WORKMANSHIP

### R11:1 GENERALLY

1101 PRE-GLAZING of components will be permitted, but precautions are to be taken to prevent displacement of glass or compound. Submit details and obtain approval. Panes with any displaced glass or compound or with defective seals are to be re-glazed in situ.

1302 QUALITY OF WORK:

store, handle and install glass and glazing materials in accordance with manufacturers' recommendations to ensure compliance with design and performance requirements

glazing must be wind and water tight under all conditions to BS 6375 with full allowance made for deflections and other movements

panes are to be accurately sized with clean, undisfigured and undamaged edges and surfaces

keep materials dry until fixed

ensure that glass, surround materials, primers, sealers and paints which are to be used together are compatible

preparation of surrounds, dimensions of edge cover and clearance, positions and materials of distance pieces, setting and location blocks are to be BS 6262 and to glass and sealant manufacturers' recommendations.

1401 GLAZING GENERALLY is to be to BS 6262.

1405 SECURITY GLAZING is to be to BS 5357.

## R11:2 FIXING GENERALLY

2101 PREPARATION: all surfaces to receive glazing are to be clean, dry, unobstructed and free from grease at time of priming, sealing and glazing. Allow primers or sealers to dry between coats and before glazing. Ensure that priming or sealing by others has been carried out and, if unsatisfactory, report to the Engineer before glazing commences.

2501 BEAD FIXING: fix beads at pre-determined centres in accordance with surround manufacturer's recommendations, unless otherwise specified.

## R11:3 GLAZING METHODS

3051 SETTING AND LOCATION BLOCKS: locate as per BS 6262, figure 22.

3055 DISTANCE PIECES: locate as per BS 6262, figure 23.

3101 NON-SETTING OR RUBBERIZING COMPOUNDS:

fully bed glass and beads in compound and fix beads securely

trim excess compound to form smooth, neat chamfer.

3201 TAPES AND CAPPING SEALANT:

apply tape of sufficient thickness to produce minimum 3 mm bed both sides of glass after compression; butt joint tape at corners, leaving no gaps; use tape of sufficient width to fill inside joint after compression and to finish approximately 6 mm below sight line on outside to receive capping sealant

bed beads to frame in bedding sealant, filling all voids, press firmly into position to compress tape and fix securely

trim excess tape to a smooth chamfer

apply capping sealant to fill outside joint, finishing to a smooth chamfer.

3401 GASKETS (CHANNEL TYPE):

ensure that fixing surfaces are smooth, undistorted and free from burrs, weld spatter and projections; any required painting is to be carried out before glazing

lay out gaskets in flat, warm area for 24 hours before glazing

ensure that edges of glass are arrissed or covered with self-adhesive tape

fit gasket to frame, butt jointing any ends in centre of top of opening, leaving no gaps

lubricate gaskets and zipper strips with water or liquid paraffin

insert glass carefully using hardwood or plastic spatulas

equalise edge clearance with setting blocks

insert zipper strips and allow to retract for at least 4 hours before mitring corners and pushing into position, leaving no gaps.

3501 FIRE-RESISTANT CHANNELS:

fit channel firmly to glass with butt jointed corners, bedding glass in an approved material if necessary to ensure tight fit; bed channel to surround in intumescent mastic

fix channels with screws at 100 mm staggered centres, evenly spaced and 50 mm from each corner

seal any gaps with intumescent mastic.

3801 MIRRORS:

fix accurately and securely, but do not overtighten fastenings

ensure undistorted reflection both within and between adjoining panes.

R11:4 PROTECTION AND CLEANING

4101 INDICATORS: do not use painted or stuck on indicators on solar control or coloured glass. Whitewash on ordinary glass must be restricted to small central areas of panes.

4201 CLEANING: remove cement and plaster based spillage whilst wet. Remove all smears and excess glazing materials. Leave glazing clean and free from scratches inside and out.

4251 CLEANING PLASTICS GLAZING SHEET: remove dirt and grime using tepid soap or detergent solution. Remove fresh paint, grease and glazing compounds using solvents recommended by sheet manufacturer.

4501 DAMAGE: replace all glass and fixing materials broken or damaged before substantial completion, and redecorate.

# V11 PAINTING AND CLEAR FINISHING

## GENERAL

### V11:A SCOPE

A105 SCOPE: this Section is for the specification of interior and exterior painting (thin surface film coatings). It does not include painting to structural steel works.

### V11:D DEFINITIONS

D115 SILK FINISH: a surface finish, associated with emulsion paints that has greater sheen than a matt finish.

D120 MATT FINISH: a surface finish, associated with emulsion paints that have little or no sheen.

D130 GLOSSARY of building terms related to painting shall be as per BS 2015.

### V11:E SUBMITTALS

E105 PRODUCT DATA: submit manufacturer's technical information, label analysis, and application instructions for each material proposed for use. Submit evidence that proposed paints satisfy the performance requirements for of paints as specified hereafter. List each material and cross-reference the specific coating and finish system and application. Identify each material by the manufacturer's catalogue number and general classification.

E110 PRODUCT TEST DATA: submit laboratory test reports for tests conducted in accordance with relevant test procedures listed in latest update to BS EN 23270, BS EN ISO 6272 and BS 3900 and its parts on representative samples taken by the Engineer from each type of paint, for the following properties:

Quantitative and chemical material analysis:

total solid content
pigment type and content
extender type and content
binder type and content

Opacity (hiding power)

abrasion resistance

adhesion

resistance to household chemicals (special coatings)

wet abrasion resistance, Scrubbing Method (latex paints)

exposure resistance (exterior paints)

E115 SUBSTITUTION REQUESTS: submit three copies of each request for consideration. Identify product to be replaced. Include detailed comparison between specified and proposed paint. Comparison to include:

chemical composition and properties.
opacity.
cleanability.
scrub resistance wet and dry
adhesion.
exposure resistance.

V11:F QUALITY ASSURANCE

F105 MANUFACTURER QUALIFICATIONS: a firm experienced in manufacturing paints similar to those indicated for this Project and with a record of successful in-service performance, as well as sufficient production capacity to manufacture required quantity.

F110 Products specified refer to products manufactured in the country of origin. Manufacturers producing in other countries under license shall submit evidence that the products manufactured under license are identical in all respects to the original products manufactured in the country of origin.

F112 APPLICATOR QUALIFICATIONS: engage an experienced applicator who has completed painting system applications similar in material and extent to that indicated for this Project with a record of successful in-service performance. Include project names and addresses, names and addresses of Consultants and Employers, and other information specified

F115 SOURCE LIMITATIONS: obtain fillers, primers, and undercoat materials for each coating system from the same manufacturer as the finish coats and as recommended by him.

F120 PERFORMANCE OF PAINTS: paints shall be fit for purpose and manufactured specifically for the applications indicated and uses intended, taking into account the type, nature, location, and aesthetic and utility requirements of the Project, as follows:

Opacity: paint shall cover or hide the substrate to the Engineer's satisfaction.

Cleanability: paint shall not absorb dirt and shall be capable of being washed or scrubbed periodically, to the Engineer's satisfaction, without adverse effect on its attributes or appearance.

Scrub resistance wet and dry: paint shall resist abrasion caused by scrubbing in accordance with ASTM D 2486.

Adhesion: paint shall adhere firmly to the substrate without peeling.

Exposure resistance: paint shall resist yellowing and weathering caused by UV rays and ozone.

F125 BENCHMARK SAMPLES (MOCKUPS): provide a full-coat benchmark finish sample of each type of coating and substrate required on the Project. Duplicate finish of approved prepared samples.

After permanent lighting and other environmental services have been activated, the Engineer will select room(s) or surface(s) to represent conditions for each type of coating and substrate to be painted.

After finishes are accepted, the Engineer will use the room or surface to evaluate coating systems of a similar nature.

Final approval of colors will be from job-applied samples.

V11:G : MAINTENANCE MATERIALS

G101 At project completion provide full unopened cans of surplus paint, properly labelled and identified for Employer’s later use in maintenance. Store where directed.

## V11:H GUARANTEE

H105 General Guarantee: The special guarantee specified in this Article shall not deprive the Employer of other rights the Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other guarantees made by the Contractor under requirements of the Contract Documents.

H110 Provide complete painting system guarantee in which Manufacturer, Contractor and Installer are jointly and severally responsible and agree to repair or replace without limitations, all or any part of paint coatings that fail in materials or workmanship within the specified guarantee period. Contractor and Manufacturer shall reimburse the Employer for the cost of material and labor. Failures include, but are not limited to:

Peeling or blistering of paint film.
Cracking of pain film.
Crazing of pain film
Efflorescence.
Change in colour.
Staining.
Patchiness of sheen or colour.

H120 Guarantee Period for Paint Coatings: 5 years from the date of Substantial Completion.

## MATERIALS AND PRODUCTS

## V11:V1 COATING MATERIALS

V105 MANUFACTURER: coating materials are to be approved brands and obtained from one approved manufacturer unless otherwise specified. Inform the Engineer of proposed manufacturer at an early date.

Man: Hempel Paints [http://www.hempel.com/]
Man: Jotun AS [http://www.jotun.com/]
Man: PPG Industries, Pittsburgh Paints [http://www.ppg.com/en/Pages/default.aspx]

or other equal and approved.

V110 COATING MATERIALS: to be delivered in sealed containers, clearly labelled with the following information:

type of material

brand name, if any
intended use
manufacturer's batch numbers.

V111 COATING MATERIALS: where possible are to be from one manufacturing batch. Where more than one batch is to be used, keep separate, allocate to distinct parts or areas of the work and inform the Engineer accordingly

V115 BATCH DELIVERIES OF COATING MATERIALS: to be dated for use in order of delivery.

V120 STORE materials in a clean, dry area protected from extreme temperatures.

V130 COATING MATERIALS GENERALLY: check that materials to be used are recommended by their manufacturers for the particular substrate and conditions of exposure, and that they are compatible with each other. Inform the Engineer of any discrepancy and obtain instructions before proceeding with application of coatings.

V135 MATERIAL QUALITY: provide the manufacturer's best quality trade sale paint material of the various coating types specified. Paint material containers not displaying manufacturer's product identification will not be acceptable.

proprietary names used to designate colors or materials are not intended to imply that products named are required or to exclude equal products of other manufacturers.

British, European or ISO Standards establishes a minimum quality level for paint materials, except where other product identification is used. Provide written certification from the manufacturer that materials provided meet or exceed these criteria.

product to be selected from manufacturer's line is to have the highest value of solid and binder content of the specified range.

Where painting, or repainting, is carried out in occupied areas, provide odourless paints.

Paints from North American manufacturers shall be certified by MPI. Paints from European manufacturers shall have agreement certificate.

V140 PIGMENT: the basic pigment is to be Titanium Dioxide Rutile to ASTM D 476, Types III or IV. Type III is to be used for interior paints whereas type IV is to be used for exterior paints.

V145 EXTENDER PIGMENT: no extender pigments or inert fillers other than barayte, mica or talc.

## V11:V2 PRIMERS AND PREPARATION MATERIALS

V205 PRIMERS: provide manufacturer's recommended factory-formulated primers that are compatible with the substrate and finish coats indicated. Primers shall be the product recommended by the manufacturer of finishing paint.

V212 PRIMER FOR WOOD: solvent-borne priming paint to BS 7956 type A, to provide high moisture resistance and suitable for use with type of wood and preservative treatment. Primer shall be appropriate type recommended by the manufacturer of finishing paint. For resinous timbers apply sealer designed to block resin exudations and extractives

V215 Corrosion protection of steel by protective paint system shall be to BS EN ISO 12944- 1 to 8.

V220 FERROUS METAL PRIMERS: appropriate type epoxy zinc-rich primers conforming to BS 4652, for priming ferrous metals and under high-gloss alkyd enamels. Zinc dust in base component shall conform to BS EN ISO 3549. Content of zinc metal in dry film shall be not less than 85% of cured paint film

V225 GALVANISED METAL PRIMERS: appropriate type epoxy zinc-rich primers conforming to BS 4652 applied after an etching primer recommended by coating system manufacturer

V260 GALVANISED METAL PRIMERS: wash or etch primer to BS 2X 32 used to prepare interior and exterior zinc-coated (galvanised) metal surfaces to receive metal primer, are to be alcoholic solution of resin, zinc chromate and phosphoric acid.

V270 CONCRETE AND MASONRY PRIMERS: interior and exterior, flat, Acrylic-based primer-sealer, under flat, semi-gloss or full gloss alkyd enamel. Primer-sealer shall be the product recommended by the manufacturer of finishing paint.

Man : Hempel Paints [http://www.hempel.com/]
Ref: Hempel's Primer/Sealer 28830; water borne.

Man : Jotun AS [http://www.jotun.com/]
Ref: Jotashield Alkali Resistant Primer.

or other equal and approved.

V275 CONCRETE AND MASONRY PRIMERS: interior and exterior acrylic latex primer coating conditioner for chalking surfaces. Conditioning primer shall be the product recommended by the manufacturer of finishing paint.

V280 GYPSUM DRYWALL PRIMER: white, interior, latex-based primer shall be the product recommended by the manufacturer of finishing paint.

V285 FILLERS: Fillers in powder form for mixing with water and consisting of acrylic resins and appropriate fillers. It is to be used on interior concrete or plastered wall surfaces as recommended for particular purpose by the paint manufacturer. Adherence to wall surfaces is not to be less than 50 N/cm$^2$.

Man: Jardin-Toupret
Ref: Top1, Top2

or other equal and approved.

V290 FILLERS: Oil-based proprietary fillers in paste form consisting of alkyd resins and appropriate fillers. It is to be used on primed interior / exterior wood as recommended for particular purpose by the paint manufacturer. Adherence is not to be less than 50 N/cm$^2$

Man: Jardin-Toupret
Ref: Top1, Top2

or other equal and approved.

V11:V3 UNDERCOAT MATERIALS

V305 UNDERCOAT MATERIALS: provide paint manufacturer's recommended factory-formulated undercoat materials that are compatible with the substrate and finish coats indicated. Undercoat and finishing paints shall be to BS 7664

V310 INTERIOR ENAMEL UNDERCOAT: ready-mixed enamel complying with TT-E-545, for use as an undercoat over wood, hardboard, ferrous or zinc-coated metal under an odorless alkyd semi-gloss enamel or full gloss alkyd enamel

V315 INTERIOR ENAMEL UNDERCOAT: ready-mixed enamel complying with FS-TT-E-545B, for use under high gloss, semi-gloss, flat and latex paint.

## V11:V4 EXTERIOR FINISH PAINT MATERIALS

V405 FINISH PAINT: provide paint manufacturer's recommended factory-formulated finish-coat materials that are compatible with the substrate and undercoats indicated. Undercoat and finishing paints shall be to BS 7664.

V410 EXTERIOR ACRYLIC EMULSION: Pure acrylic exterior resin based emulsion to produce a durable, flexible and water-resistant coating suitable for repeated washing and scrubbing. The white pigment shall consist of titanium dioxide Rutile.

Man : Hempel Paints [http://www.hempel.com/]
Ref: Hempel's Acrylic Silk Emulsion 58260; water borne.
Ref: Hempel's Acrylic Gloss Emulsion 58650; water borne.

Man : Jotun AS [http://www.jotun.com/]
Ref: Jotashield pure acrylic emulsion.

or other equal and approved.

V450.NATURAL-FINISH WOODWORK: provide polyurethane varnish natural finishes over new, interior woodwork.

Man: Hempel Paints [http://www.hempel.com/]
Ref: Hempel's P/U Lacquer 05570; Interior/ Exterior gloss

or other equal and approved.

## V11:V5 INTERIOR FINISH PAINT MATERIALS

V505 FINISH PAINT: provide paint manufacturer's recommended factory-formulated finish-coat materials that are compatible with the substrate and undercoats indicated. Undercoat and finishing paints shall be to BS 7664.

V510 INTERIOR ACRYLIC EMULSION: Interior acrylic resin based emulsion to produce a durable, Satin, flexible and water-resistant coating suitable for repeated washing and scrubbing. The white pigment shall consist of titanium dioxide Rutile.

Man: Hempel's Acrylic Silk Emulsion 58260

or other equal and approved.

V525 INTERIOR, SEMIGLOSS ALKYD ENAMEL: oleo-resinous, alkyd paint to FS- A-A-50574 (MPI 47). Paint is to be non-toxic, drying to a smooth, highly opaque surface to produce a durable, flexible and water-resistant coating with excellent adhesion and colour retention. The white pigment shall consist of titanium dioxide to ASTM D 476, Types III or IV. Undercoat is to be suitable to receive further coatings. Finish is to be semi-gloss as selected by the Engineer. The minimum constituent properties are to be as follows:

| | |
|---|---|
| total pigment, percent by weight of non volatile : | 37 %- 42 % |
| titanium dioxide pigment: | 300 g/l |

V530.NATURAL-FINISH WOODWORK: provide polyurethane varnish natural finishes over new, interior woodwork.

Man: Hempel Paints [http://www.hempel.com/]
Ref: Hempel's P/U Lacquer 05570; Interior/ Exterior gloss

or other equal and approved.

## WORKMANSHIP

### V11:1 GENERALLY

1051 STANDARD: work in this Section is to be executed generally in accordance with BS 6150 and BS 8000-12.

1101 QUALITY OF WORK: operatives must be appropriately skilled and experienced in the use of specified materials and methods of application. Prepare surfaces and apply coatings in accordance with manufacturers' recommendations.

1151 COMPATIBILITY:

where surfaces have been treated with preservatives, check with treatment manufacturer that coating materials are compatible with the treatment and do not inhibit its performance

inform the Engineer of any discrepancy in specification of coatings and obtain instructions before proceeding with application.

1201 COATING GENERALLY

Application standard: In accordance with BS 6150, clause 9.

Conditions: Maintain suitable temperature, humidity and air quality during application and drying.

Surfaces: Clean and dry at time of application.

Thinning and intermixing of coatings: Not permitted unless recommended by manufacturer.

Overpainting: Do not paint over intumescent strips or silicone mastics.

Priming coats:

Thickness: To suit surface porosity.
Application: As soon as possible on same day as preparation is completed.

Finish:

Even, smooth and of uniform colour.
Free from brush marks, sags, runs and other defects.
Cut in neatly.

Doors, opening windows and other moving parts: Ease before coating and between coats.

1251 COLOUR RANGE: carry out decoration in colours to BS 4800 or within range produced by particular coating manufacturer as appropriate and as selected by the Engineer.

1301 OFF SITE WORK: off site preparation and coating is to be carried out under cover in a suitable environment with adequate lighting. Store all items, both before and after coating, in a clean, dry area protected from the weather and mechanical damage, properly stacked with spaces to permit air circulation and prevent sticking of surfaces.

1351 PROTECTION: adequately protect both internal and external surfaces which are not to be coated, by covering with dust sheets or other suitable materials. Exhibit 'wet paint' signs and provide barriers where necessary to prevent damage to freshly applied coatings.

1401 TESTING OF VISCOSITY ETC.: the Engineer may, at his discretion, take samples of materials from each manufacturing batch as follows:

unopened tins or samples from previously unopened tins, for submission to manufacturer for comparison with manufacturer's own retained samples from the same batch

unopened tins or samples from previously unopened tins, as a control sample for assessment of samples taken from painters' kettles

samples from painters' kettles for submission (with the samples described in the previous item) to manufacturer and/or independent testing laboratory for comparative testing.

1451 INSPECTION OF WORK: if requested by the Engineer, permit coating manufacturers to inspect the work in progress and take samples of their products from site, for testing.

1502 INSPECTION OF WORK: inspection of the whole of the work at each stage may be made, at the discretion of the Engineer. Agree with the Engineer a programme which will facilitate such inspections and notify him when each part and stage of the work is ready for inspection. Do not proceed with subsequent stages of the work until authorized.

## V11:2 PREPARATION

### 2051 PREPARATION GENERALLY

Standard: To BS 6150, Section 4.

Preparation materials: Types recommended by their manufacturers and the coating manufacturer for the situation and surfaces being prepared.

Substrates: Sufficiently dry in depth to suit coating.

Efflorescence salts: Remove.

Dirt, grease and oil: Remove. Give notice if contamination of surfaces/ substrates has occurred.

Surface irregularities: Abrade to a smooth finish.

Joints, cracks, holes and other depressions: Fill with stoppers/ fillers. Work well in and finish off flush with surface. Abrade to a smooth finish.

Dust, particles and residues from abrasion: Remove. Fill with stoppers/ fillers. Work well in and finish off flush with surface. Abrade to a smooth finish.

Water based stoppers and fillers: Apply before priming unless recommended otherwise by manufacturer. If applied after priming: Patch prime.

Doors, opening windows and other moving parts: Ease, if necessary, before coating. Prime resulting bare areas.

2101 FIXTURES AND FITTINGS:

Replacement: Refurbish as necessary, refit when coating is dry.

2105 IRONMONGERY

Removal: Before commencing work: Remove ironmongery from surfaces to be coated.

Hinges: remove.

Replacement: Refurbishment as necessary; refit when coating is dry.

2201 CONCRETE: remove release agents by washing with weak detergent solution and rinse off with clean water. Fill blow holes and other surface defects and rub down flush with surface.

2251 MASONRY: remove dirt, surface deposits, loose and flaking material with a stiff brush. Fill holes and cracks and rub down flush with surface.

2301 CEMENT-SAND PLASTER: remove dirt and surface deposits with a stiff brush. Rub down to remove nibs, trowel marks and plaster splashes. Lightly rub over-trowelled glossy plaster with worn abrasive paper. Apply and spread filler to the entire surface and rub down to leave completely smooth and flush, free from depressions, coarse-grained surfaces and other imperfections.

2351 GYPSUM PLASTER: remove dirt and surface deposits with a soft brush. Rub down to remove nibs, trowel marks and plaster splashes. Lightly rub over-trowelled glossy plaster with worn abrasive paper. Fill all depressions, coarse-grained surfaces, holes and cracks and lightly rub down flush with surface.

2401 PLASTERBOARD: fill imperfections and/or minor damage to leave a smooth, blemish-free surface.
2451 CHALKING SURFACES: prepare surfaces in accordance with manufacturer’s instructions. Apply one coat of primer coating conditioner.

2501 UNCOATED STEEL - BLAST CLEANING: remove oil and grease by washing with white spirit or steam. Blast clean in dry atmospheric conditions using chilled iron grit to BS EN ISO 8501and BS EN ISO 11124-2 of suitable size, free from fines, moisture and oil. Continue blasting until finish complies with BS EN ISO 8501- A1 , second quality finish. Remove abrasive residues. Prime surface as soon as possible after cleaning and in any case within 4 hours.

2511 UNCOATED STEEL - MANUAL CLEANING: where conditions preclude blast cleaning, prepare uncoated steel manually by chipping, scraping and wire-brushing surfaces to remove loose rust, loose scale, welding slag and spatter. Clean out crevices. Remove oil, grease and dirt with white spirit, avoiding spreading it over the surface. Remove residual rust with suitable chemical treatment, applying primer as soon as it has cured.

2551 PRE-PRIMED STEEL: remove dirt and grease from satisfactorily pre-primed surfaces. Remove any defective primer, rust and loose scale back to bare metal and patch prime to match existing.

2601 GALVANISED SURFACES: Clean galvanised surfaces with non-petroleum-based solvents so that the surface is free of oil and surface contaminants. Remove pre-treatment from galvanised sheet metal fabricated from coil stock by mechanical methods. Apply wash primer if recommended by manufacturer of coating system.

2651 ALUMINIUM: remove any surface corrosion with fine abrasive paper lubricated with white spirit. Wash with white spirit to remove dirt and grease and apply etching primer to provide key. Small areas may be rubbed down to provide key.

2701 UNCOATED WOOD:

ensure that large and loose knots are removed and made good with sound wood of the same species and sand down flush

ensure that surfaces are clean and remove oil, grease and excessive natural oils with suitable solvents

sand to a smooth, even finish with arrises rounded or eased

remove resinous exudations by heat, apply two coats of knotting to resinous areas and knots and allow to dry

ensure that heads of fastenings are countersunk sufficiently to hold stopping/filling; fill nail and screw holes, joints, cracks, holes, depressions, open or coarse grain with stopper/filler worked well in and finished off flush with surface; sand smooth and remove dust.

2711 PRIMING WOOD: before priming preservative treated wood ensure that any cut surfaces have been re-treated and solvents have completely dried out. Apply primer to all surfaces including rebates, beads, backs etc. which will be concealed when components are fixed in place. Liberally coat all end grain, allow to soak in and then re-coat.

2751 PRE-PRIMED WOOD: remove dirt and grease from satisfactorily pre-primed surfaces and sand lightly. Sand down chalking, powdery and other defective areas to the bare surface, remove dust and re-prime as necessary.

2801 STOPPING, FILLING AND PRIMING: apply oil based stoppers/fillers after priming. Apply water based stoppers/fillers before priming unless otherwise recommended by manufacturer. Use proprietary materials in accordance with manufacturer's printed recommendations. Patch prime water based stoppers/fillers when applied after priming.

2811 STOPPER/FILLER FOR CLEAR COATINGS: carefully adjust colour so that after coatings have been applied it closely matches the colour of the wood, to approval.

2815 CONCEALED METAL SURFACES: apply black bitumen coating solution to concealed surfaces of metal components before fixing.

2817 EXTERNAL DOORS: prime and paint bottom edges before hanging.

2821 REBATES AND BEADS OF WOODWORK which is to be varnished must have the first two coats of varnish applied before glazing.

2822 IRONMONGERY: remove from surfaces to be coated and re-fix on completion. Do not remove hinges unless instructed to do so.

2825 DOORS AND WINDOWS: ensure that doors and opening windows etc. are eased as necessary before coating. Prime any resulting bare areas.

2827 Coating Of Concealed Joinery Surfaces

Workshop Coating Of Concealed Joinery Surfaces: General: Apply coatings to all surfaces of components.

Site Coating Of Concealed Joinery Surfaces: After priming, apply additional coatings to surfaces that will be concealed when fixed in place.

2831 COATING OF CONCEALED METAL SURFACES: general: apply additional coatings to surfaces that will be concealed when component is fixed in place.

V11:3 APPLICATION

3051 COATING GENERALLY

Application standard: To BS 6150, Section 5.

Conditions: Maintain suitable temperature, humidity and air quality during application and drying.

Surfaces: Clean and dry at time of application.

Thinning and intermixing of coatings: Not permitted unless recommended by manufacturer.

Overpainting: Do not paint over intumescent strips or silicone mastics.

Priming coats:
Thickness: To suit surface porosity.
Application: As soon as possible on same day as preparation is completed.

Finish:
Even, smooth and of uniform colour.
Free from brush marks, sags, runs and other defects.
Cut in neatly.

3101 GENERAL: apply paint according to manufacturer's directions. Use applicators and techniques best suited for substrate and type of material being applied.

3105 GENERAL: do not paint over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions detrimental to formation of a durable paint film:

apply priming coats as soon as possible on the same day as preparation is completed; ensure that they are of adequate thickness and suit surface porosity

surface treatments and finishes are indicated in the schedules

provide finish coats that are compatible with primers used

the number of coats and the film thickness required are the same regardless of the application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. Sand between applications where sanding is required to produce a smooth even surface according to the manufacturer's directions

apply additional coats if undercoats, stains, or other conditions show through final coat of paint until paint film is of uniform finish, colour, and appearance. Give special attention to ensure that surfaces, including edges, corners, crevices, welds, and exposed fasteners, receive a dry film thickness equivalent to that of flat surfaces

the term exposed surfaces includes areas visible when permanent or built-in fixtures, convector covers, covers for finned tube radiation, grilles, and similar components are in place. Extend coatings in these areas, as required, to maintain the system integrity and provide desired protection

paint surfaces behind movable equipment and furniture the same as similar exposed surfaces. Before final installation of equipment, paint surfaces behind permanently fixed equipment or furniture with prime coat only

paint interior surfaces of ducts, where visible through registers or grilles, with a flat, non specular black paint

paint back sides of access panels and removable or hinged covers to match exposed surfaces

finish interior of wall and base cabinets and similar field-finished casework to match exterior

finish exterior doors on tops, bottoms, and side edges same as exterior faces

sand lightly between each succeeding enamel or varnish coat

omit primer on metal surfaces that have been shop-primed and touch-up painted

apply coatings evenly to give smooth finish of uniform colour, free from brush marks, nibs, sags, runs and other defects; cut in neatly and cleanly; do not splash or mark adjacent surfaces.

3110 SCHEDULING PAINTING: apply first coat to surfaces that have been cleaned, pre treated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration. Allow sufficient time between successive coats to permit proper drying. Do not recoat until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and where application of another coat of paint does not cause the undercoat to lift or lose adhesion.

3115 APPLICATION PROCEDURES: apply paints and coatings by brush, roller, spray, or other applicators according to the manufacturer's directions:

| | | |
|---|---|---|
| brushes | : | use brushes best suited for the material applied |
| rollers | : | use rollers of carpet, velvet back, or high-pile sheep's wool as recommended by the manufacturer for the material and texture required |
| spray equipment | : | use airless spray equipment with orifice size as recommended by the manufacturer for the material and texture required. |

3120 APPLICATION BY BRUSH: the first, or priming, coat is to exhibit easy brushing and lapping properties. The succeeding coats applied over the first is to show easy brushing and good flowing, spreading and lapping properties and it shall exhibit no undue pull under the brush and show no floating, sagging, running or dripping.

3125 APPLICATION BY ROLLER: the first, or priming, coat is to exhibit easy rolling, leveling and lapping properties. The succeeding coats applied over the first is to show easy rolling and good flowing, spreading and lapping properties and it shall exhibit no undue pull under the brush and show no floating, sagging, running or dripping.

3130 APPLICATION BY SPRAY: when applied by spray after thinning with the manufacturer’s recommended thinner, the first coat is to exhibit satisfactory spraying. The succeeding coats applied over the first is to show easy spraying and good flowing, and lapping properties and it shall show no floating, sagging, running or dripping.

3135 MINIMUM COATING THICKNESS: apply materials no thinner than the manufacturer's recommended spreading rate. Provide the total dry film thickness of the entire system as recommended by the manufacturer, unless otherwise specified. Check wet film thickness with wet film gauge.

3140 PRIME COATS: before applying finish coats, apply a prime coat of material, as recommended by the manufacturer, to material that is required to be painted or finished and that has not been prime-coated by others. Re-coat primed and sealed surfaces where evidence of suction spots or unsealed areas in first coat appears, to ensure a finish coat with no burn-through or other defects due to insufficient sealing.

3145 PIGMENTED (OPAQUE) FINISHES: completely cover to provide a smooth, opaque surface of uniform finish, colour, appearance, and coverage. Cloudiness, spotting, holidays, laps, brush marks, runs, sags, ropiness, or other surface imperfections will not be acceptable.

3150 TRANSPARENT (CLEAR) FINISHES: use multiple coats to produce a glass-smooth surface film of even luster. Provide a finish free of laps, cloudiness, colour irregularity, runs, brush marks, orange peel, nail holes, or other surface imperfections:

provide satin finish for final coats.

3155 COMPLETED WORK: match approved samples for colour, texture, and coverage. Remove, refinish, or repaint work not complying with specified requirements.

3201 STAINING WOOD

Primer: Apply if recommended by stain manufacturer.

Application: Apply in flowing coats and brush out excess stain to produce uniform appearance.

3251 VARNISHING: thin first coat with white spirit in accordance with manufacturer's recommendations. Brush well in, avoiding aeration, and lay off. Apply two further coats of varnish, rubbing down lightly between coats along the grain.

3601 UNSUITABLE CONDITIONS: do not apply coatings to surfaces affected by moisture, when relative humidity is more than 80% or when heat is likely to cause blistering or wrinkling. Take necessary precautions including restrictions on working hours, providing temporary protection and allowing extra drying time, to ensure that coatings are not adversely affected by climatic conditions before, during and after application.

3851 GLAZING: protect etched, sand blasted and ground glass from attack by oily constituents of coating materials by treating edges before coating and cleaning surfaces after coating.

3901 COMPLETION: ensure that opening lights and other moving parts move freely. Remove all masking tape and protective wrappings.

V11:4 EXTERIOR PAINT SCHEDULE:

4051 GENERAL: provide the following paint systems for the substrates indicated, applied at spreading rates recommended by the manufacturer to achieve specified finishes.

4505 CONCRETE, MASONRY, AND PLASTER: Acrylic Emulsion: 2 coats with total dry film thickness not less than 0.06 mm [2.5 mils]

Primer: Acrylic non-pigmented primer sealer

First Coat: Acrylic Emulsion Ext.

Second Coat: Acrylic Emulsion Ext.

4551 WOOD: Alkyd Gloss Finish: 2 finish coats over primer.

Primer: Alkyd Primer Coating

First Coat: Alkyd Gloss Enamel

Second Coat: Alkyd Gloss Enamel

4601 FERROUS METAL: Alkyd Gloss Enamel: 2 finish coats over primer. Primer is not required on shop-primed items.

Primer: Zinc Rich Primer

First Coat: Alkyd Gloss Enamel

Second Coat: Alkyd Gloss Enamel

4701 ZINC-COATED METAL: High-Gloss Alkyd Enamel: 2 finish coats over primer.

Primer: Galvanised metal primer
First Coat: Alkyd Gloss Enamel

Second Coat: Alkyd Gloss Enamel

V11:5 INTERIOR PAINT SCHEDULE:

5051 GENERAL: provide the following paint systems for the substrates indicated, applied at spreading rates recommended by the manufacturer to achieve specified finishes.

5101 CONCRETE, MASONRY, AND PLASTER:

Satin Emulsion Finish: 2 coats.

Primer: latex-based non-pigmented primer sealer

Filler

First Coat: Acrylic Emulsion

Second Coat: Acrylic Emulsion

5201 GYPSUM DRYWALL SYSTEMS:

Lusterless (Flat) Emulsion Finish: 2 coats.

Primer: Latex-Based Interior White Primer

Filler

First Coat: Acrylic Emulsion

Finish Coat: Acrylic Emulsion

5401 WOODWORK AND HARDBOARD:

Natural-Finish Woodwork: 4 coats.

Filler Coat: Paste-wood filler

Sealer Coat: Clear sanding sealer

First Finish Coat: polyurethane varnish

Second Finish Coat: polyurethane varnish

5701 FERROUS METAL:

Semigloss Enamel Finish: 2 coats over primer with total dry film thickness not less than 0.063 mm [2.5 mils].

Primer: Zinc Rich Primer

Undercoat: Interior Enamel Undercoat

Finish Coat: Interior Semigloss Odorless Alkyd Enamel

5801 ZINC-COATED METAL:

Semigloss Finish: 2 coats over primer, with total dry film thickness not less than 0.063 mm [2.5 mils].

Primer: Galvanised Metal Primer

Undercoat: Interior Enamel Undercoat

Finish Coat: Interior Semigloss Odorless Alkyd.

# V13 INTUMESCENT PAINTS

## GENERAL

### V13:A SCOPE

A105 SCOPE: This Section includes surface preparation and application of intumescent paints to scheduled items and surfaces, including prime and finish coats.

### V13:C SUBMITTALS

C101 Product Data: For each intumescent paint system indicated. Include block fillers and primers.

Material List: Provide an inclusive list of required intumescent paint materials. Indicate each material and cross-reference specific coating, finish system, and application. Identify each material by manufacturer's catalog number and general classification.

Manufacturer's Information: Provide manufacturer's technical information, including label analysis and instructions for handling, storing, and applying intumescent paint materials.

Submit evidence that paints proposed for use satisfy requirements for performance of paints as specified hereafter.

Samples for Initial Selection: Manufacturer's color charts showing the full range of colors available for each intumescent paint finish indicated.

After color selection, the Engineer will furnish color chips for surfaces to be coated.

Samples for Verification: For each color to be applied, with texture to simulate actual conditions, on representative samples of the actual substrate.

Provide stepped Samples, defining each separate coat, including block fillers, primers, and finish coats. Use representative colors when preparing Samples for review. Resubmit until required sheen, color, and texture are achieved.

Provide a list of materials and applications for each coat of each finish sample. Label each sample for location and application.

Submit Samples on the following substrates for the Engineer's review of color and texture only:

Concrete and Masonry: Two 100-mm- square samples of actual substrate material for each color and texture.

Concrete Masonry: Two 200-mm- square samples of concrete masonry, with mortar joint in the center, for each color and texture.

Wood: Two 300-mm- square samples of each color and texture on hardboard.

Ferrous Metal: Two 100-mm- square samples of flat metal, and two 200-mm- long samples of solid metal for each color and finish.

C105 Qualification Data: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed projects with project names and addresses, names and addresses of architects and owners, and other information specified.

C110 Installer Certificates: Signed by product manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install his products.
Installer Experience: List of five projects (minimum) of a similar nature carried out successfully by the installer with the same product endorsed by the manufacturer's representative.

C115 Product Test Reports: From a qualified testing agency indicating that intumescent paint materials comply with requirements indicated, based on comprehensive testing of current product formulations. Ageing tests ,on site, shall be conducted by the testing agency at intervals to demonstrate to demonstrate that the intumescent paint has not deteriorated.

C120 SUBSTITUTION REQUESTS: Coordinate with requirements in Division one and submit three copies of each request for consideration. Identify product to be replaced. Include detailed comparison between specified and proposed paint. Comparison to include:

Fire rating.
Chemical composition and properties.
Opacity.
Cleanability.
Scrub resistance wet and dry
Adhesion.
Exposure resistance.

## V13:D QUALITY ASSURANCE

D105 Applicator Qualifications: An experienced applicator who has completed intumescent painting applications similar in material and extent to that indicated for the Project with minimum three years documented experience and that is approved, authorized, or licensed by the product manufacturer to apply his product and that is eligible to receive manufacturer's warranty. Include project names and addresses, names and addresses of Engineers and Employers, and other information.

D110 Source Limitations: Obtain block fillers, primers, and undercoat materials for each intumescent paint system from the same manufacturer as the finish coats.

Notify the Engineer of problems anticipated using specified coating systems.

D115 Fire-Test-Response Characteristics: Provide intumescent paint materials with the following surface-burning characteristics as determined by testing identical products per ASTM E 84 or BS476-7 by UL or another testing and inspecting agency acceptable to authorities having jurisdiction.

Flame Spread: 25.
Smoke Developed 450.

D120 FIRE RESISTANCE: Fire resistance to BS 476-21 : 120 minutes. Intumescent coat thickness shall be determined by manufacturer to give the required protection.

D120 Benchmark Samples (Mockups): Provide a full-coat benchmark finish sample for each type of coating and substrate required. Comply with procedures specified in PDCA P5. Duplicate finish of approved sample Submittals.

The Engineer will select one wall surface for each substrate to receive intumescent paint to represent surfaces and conditions for application of each type of coating.

Wall Surfaces: Provide samples of at least 9 sq. m.

Small Areas and Items: The Engineer will designate an item or area required.

Notify the Engineer seven days in advance of dates and times when benchmark samples will be applied.

Apply benchmark samples, according to requirements for the completed Work, after permanent lighting and other environmental services have been activated.

Obtain the Engineer's approval of benchmark samples before starting intumescent paint application.

Maintain benchmark samples during construction in an undisturbed condition as a standard for judging the completed Work.
Final approval of colors will be from benchmark samples.

D125 INSPECTION: Permit intumescent coating manufacturer to:

Inspect work in progress.
Inspect quality control records.
Take dry film thickness and other measurements.
Take samples of coating products.

Intumescent coating manufacturer's inspection reports: Submit without delay.

## V13:E GUARANTEE

E105 GENERAL GUARANTEE: The special guarantee specified in this Article shall not deprive the Employer of other rights the Employer may have under other provisions of the Contract Documents and shall be in addition to, and run concurrent with, other guarantees made by the Contractor under requirements of the Contract Documents.

E110 SPECIAL GUARANTEE FOR PAINT FINISHES: Contractor and Manufacturer are jointly and severally responsible and shall agree to repair or replace paint coatings that fail within the specified guarantee period. Contractor and Manufacturer shall reimburse the Employer for the cost of material and labor. Failures include, but are not limited to:

Peeling or blistering of paint film.
Failure to protect against fire for the specified time
Cracking of pain film.
Crazing of pain film
Efflorescence.
Change in colour.
Staining.
Patchiness of sheen or colour.

Guarantee Period for Paint Coatings: 5 years from the date of Substantial Completion.

## V13:F DELIVERY, STORAGE AND HANDLING

F105 DELIVER intumescent paint materials to the Project site in manufacturer's original, unopened packages and containers bearing manufacturer's name and label, and the following information:

Product name or title of material.

Product description (generic classification or binder type).
UL label, indicating tested fire rating.
Manufacturer's stock number and date of manufacture.
Contents by volume, for pigment and vehicle constituents.
Thinning and mixing instructions.
Application instructions.
Color name and number.
VOC content.
Handling instructions and precautions.

F110 STORE MATERIALS not in use in tightly covered containers in a well-ventilated area at a minimum ambient temperature of 7.2 deg C. Maintain containers used in storage in a clean condition, free of foreign materials and residue.

Protect intumescent paint materials from freezing. Keep storage area neat and orderly. Remove oily rags and waste daily. Take necessary measures to ensure that workers and work areas are protected from fire and health hazards resulting from handling, mixing, and application.

## V13:G PROJECT CONDITIONS

G105 TEMPERATURE CONDITIONS: Apply coatings only when the temperature of surfaces to be coated and surrounding air temperatures are above 10 deg C.

G110 WEATHER CONDITIONS: Do not apply intumescent paints in snow, rain, fog or mist; or when the relative humidity exceeds 85 percent; or at temperatures less than 3 deg C above the dew point; or to damp or wet surfaces. Allow wet surfaces to dry thoroughly and attain the temperature and conditions specified before proceeding with or continuing with painting operations.

G115 PAINTING may continue during inclement weather if surfaces and areas to be painted are enclosed and heated within temperature limits specified by manufacturer during application and drying periods.

## V13:H EXTRA MATERIALS

H105 FURNISH extra intumescent paint materials from the same production run as materials applied in quantities described below. Package intumescent paint materials in unopened, factory-sealed containers for storage, and identify with labels describing contents. Deliver extra materials to the Employer.

Quantity: Furnish the Employer with an additional 5 percent, but not less than 3.78 L or 1 case, as appropriate, of each material and color applied.

Quantity: Furnish the Employer with extra intumescent paint materials in the quantities indicated below:

Flat, Latex Intumescent Paint: One case of each color applied.

Semigloss, Latex Intumescent Paint: 7.57 L of each color applied.

MATERIALS AND PRODUCTS

V11:V PAINT MATERIALS

V105 PRIME COAT: Latex-type 2 pack epoxy primers applied at the spreading rate recommended by the manufacturer to achieve a total dry film thickness of not less than 0.1 mm. primer shall give protection to the structural steel

Life to first Maintenance: Life of building for C1 environment
Life to first Maintenance: Up to 20 years in a C2 to C4 Environment

V110 INTERMEDIATE COAT: Latex-type intumescent coat to give the fire protection required and certified by the approved testing laboratory.

V115 TOP SEAL: finish and seal coat recommended by the Manufacturer

Colors: As selected by the Engineer from manufacturer's full range.

V120 BASIC FINISH: Definition: Reasonably smooth and even. Orange peel, other texture, minor runs and similar minor defects are acceptable.

V125: NORMAL DECORATIVE FINISH: Definition: Good standard of cosmetic finish generally, when viewed from a distance of 5 m or more. Minor orange peel or other texture is acceptable.

V130 HIGH DECORATIVE FINISH: Definition: High standard of evenness, smoothness and gloss when viewed from a minimum distance of 2 m.

WORKMANSHIP

## V13:1 EXAMINATION

1105 EXAMINE substrates, areas, and conditions, with the Applicator present, under which painting will be performed for compliance with paint application requirements and conditions affecting coating performance.

Proceed with intumescent paint application only after unsatisfactory conditions have been corrected and surfaces receiving paint are thoroughly dry.

Start of painting will be construed as the Applicator's approval of surfaces and conditions within a particular area.

1110 COORDINATION OF WORK: Review other Sections of these Specifications in which primers are provided to ensure compatibility of the total intumescent paint system for various substrates. On request, furnish information on characteristics of finish materials to ensure use of compatible primers.

Notify the Engineer about anticipated problems using coatings specified over substrates primed by others.

## V13:2 PREPARATION

2105 GENERAL: Remove hardware, hardware accessories, plates, machined surfaces, lighting fixtures, and similar items already installed that are not to be painted. If removal is impractical or impossible because of the size or weight of the item, provide surface-applied protection before surface preparation and painting.

After completing painting operations in each space or area, reinstall items removed using workers skilled in the trades involved.

2110 CLEANING: Before applying coatings or other surface treatments, clean substrates of substances that could impair bond of the intumescent paint systems.

Schedule cleaning and painting application so dust and other contaminates will not fall on wet, newly painted surfaces.

2115 SURFACE PREPARATION: Clean and prepare surfaces to be painted according to manufacturer's written instructions for each particular substrate condition and as specified.

Surfaces to be coated must be free of oil, grease, dirt, rust, and loose or powdery paint.

Remove oil and grease before mechanical cleaning.

Remove existing water-sensitive coatings completely. Repair cracks and gouges.

Treat previously painted slick or glossy surfaces with a strong detergent and thoroughly clean or rub with sandpaper to reduce surface shine and to promote adhesion.

Provide barrier coats over incompatible primers or remove and reprime.

Ferrous Metals: Clean ungalvanized ferrous-metal surfaces that have not been shop primed. Remove oil, grease, dirt, loose mill scale, and other foreign substances. Use solvent or mechanical cleaning methods that comply with SSPC's recommendations.

Blast steel surfaces as recommended by intumescent paint manufacturer and according to SSPC-SP 10/NACE No. 2.
Touch up bare areas and shop-applied prime coats that have been damaged. Wire-brush, clean with solvents recommended by intumescent paint manufacturer, and touch up with the same primer as the shop coat.

Galvanized Metal Surfaces: Clean galvanized metal surfaces with nonpetroleum-based solvents so surface is free of oil and surface contaminants according to manufacturer's written instructions. Remove pretreatment from galvanized sheet metal fabricated from coil stock by mechanical methods.

2120 MATERIAL PREPARATION: Mix and prepare intumescent paint materials according to manufacturer's written instructions.

Maintain containers used in mixing and applying intumescent paint in a clean condition, free of foreign materials and residue.

Stir material before application to produce a mixture of uniform density, and as required during application. Do not stir surface film into material. If necessary, remove surface film and strain material before using.

Thinning: Use only thinners recommended by manufacturer and only within recommended limits.

## V13:3 APPLICATION

3105 GENERAL: Apply intumescent paints to exposed surfaces indicated according to manufacturer's written instructions. Use applicators and techniques best suited for substrate and type of material being applied.

Colors: Paint colors, surface treatments, and finishes are indicated in the schedules in the Contract Documents. Where an item or surface is not specifically mentioned in the schedules, coat the same color as similar adjacent materials or surfaces. If a color is not designated, the Engineer will select a color from those available.

Do not apply coatings over dirt, rust, scale, grease, moisture, scuffed surfaces, or conditions indicated as unacceptable in manufacturer's written instructions, or to surfaces that are otherwise detrimental to forming an acceptable coating.

3110 SCHEDULING PAINTING: Apply first coat to surfaces that have been cleaned, pretreated, or otherwise prepared for painting as soon as practicable after preparation and before subsequent surface deterioration.

The number of coats and the film thickness required are the same regardless of the application method. Do not apply succeeding coats until the previous coat has cured as recommended by the manufacturer. If sanding is required to produce a smooth, even surface according to manufacturer's written instructions, sand between applications.

If undercoats or other conditions show through the final coat of paint, apply additional coats until paint film is of uniform finish, color, and appearance. Give special attention to ensure that edges, corners, crevices, welds, and exposed fasteners receive a dry film thickness equivalent to that of flat surfaces.

Omit primer on metal surfaces that have been shop primed or touchup painted.
Allow sufficient time between successive coats to permit proper drying. Do not recoat surfaces until paint has dried to where it feels firm, does not deform or feel sticky under moderate thumb pressure, and where applying another coat of paint does not cause the undercoat to loose adhesion.

3115 APPLICATION PROCEDURES: Apply coatings by brush, roller, spray, or other applicators according to manufacturer's written instructions.

Brushes: Use brushes best suited for the material applied. Use brush of appropriate size for the surface or item being painted.

Rollers: Use rollers made of carpet, velvet back, or high-pile sheep's wool as recommended by the manufacturer for the material and texture required.

Spray Equipment: Use airless spray equipment with orifice size as recommended by the manufacturer for the material and texture required.

3120 TINTING: Tint each undercoat a lighter shade to simplify identification of each coat when multiple coats of the same material are applied. Tint undercoats to match the color of the finish coat, but provide sufficient difference in the shade of the undercoats to distinguish each separate coat.

3125 MINIMUM COATING THICKNESS: Apply materials at not less than manufacturer's recommended spreading rate for the surface to be coated. Provide the total dry film thickness of the entire system as recommended by the manufacturer to provide surface-burning characteristics specified.

3130 FILLER COAT: Apply block filler over coarse and porous concrete masonry at a rate to ensure complete coverage with all pores filled.

3140 PRIME COAT: Before applying finish coats, apply a prime coat, as recommended by the manufacturer, to substrates required to be painted that have not been prime coated by others. Recoat primed and sealed surfaces where evidence of suction spots or unsealed areas appears in the first coat.

3150 INTUMESCENT PAINT: Apply intumescent paint by brush, roller, or spray as recommended by the coating manufacturer for the type of substrate involved according to manufacturer's written instructions.

Where multiple finish coats are required, allow the base or first coat to dry before applying topcoat according to manufacturer's written instructions.

Delete subparagraph below if no nonintumescent topcoats.

Apply nonintumescent topcoats where scheduled, using materials and application methods according to manufacturer's written instructions.

3160 COMPLETED WORK: Match approved samples for color, texture, and coverage. Removed, refinish, or repaint work not complying with specified requirements.

## V13:4 FIELD QUALITY CONTROL

4105 THE EMPLOYER reserves the right to invoke the following test procedure at any time and as often as the Employer deems necessary during the period when paint is being applied:

The Employer will engage the services of an independent testing agency to sample paint materials being used. Samples of material delivered to the Project site will be taken, identified, sealed, and certified in the presence of the Contractor.

The testing agency will perform appropriate tests for the following characteristics as required by the Employer:

Qualitative material analysis.
Absorption.
Accelerated weathering.
Accelerated yellowness.
Color retention.
Alkali resistance.
Abrasion resistance.
Mildew resistance.
Apparent reflectivity.
Washability.
Dry opacity.
Recoating.
Skinning.

The Employer may direct the Contractor to stop painting if test results show materials being used do not comply with specified requirements. The Contractor shall remove noncomplying paint materials from the Project site, pay for testing, and repaint surfaces previously painted with rejected materials. If necessary, the Contractor may be required to remove rejected materials from previously painted surfaces if, on repainting with the specified materials, the two coatings are incompatible.

## V13:5 CLEANING

5105 CLEAN UP: At the end of each workday, remove rubbish, empty cans, rags, and other discarded materials from the Project site.

After completing painting, clean glass and paint spattered surfaces. Remove spattered paint by proper methods. Be careful not to scratch or otherwise damage adjacent finished surfaces.

## V13:6 PROTECTION

6110 PROTECT work of other trades, whether being painted or not, against damage from painting. Correct damage by cleaning, repairing or replacing, and repainting as approved by the Engineer. Leave the work in an undamaged condition.

6115 PROVIDE "Wet Paint" signs to protect newly painted finishes. Remove temporary protective wrappings provided by others to protect their work after completing painting operations.

After completing work of other trades, touch up and restore damaged or defaced surfaces. Comply with PDCA P1.

# X10 FITTINGS

## GENERAL

### X10:A SCOPE

A105 SCOPE: this Section is for the specification of fittings (other than furniture and furnishings) fixed to the building fabric or provided loose within building spaces, together with all associated hardware, fixings, ironmongery and accessories, including:

Shelving and Storage Fittings:
- shelving

Counter Units, Worktops and Benches:
- counter units
- benches

Signs:
- internal lettering and signs
- external lettering

Sundry Fittings:
- corner guards
- dock bumper
- wall bumper / handrail
- marble toilet partitions
- door mats and frames

### X10:C SUBMITTALS

C105 PRODUCT DATA: submit manufacturer's product data and specifications for each type of fitting, including construction details, material descriptions, dimensions of individual components and profiles, together with charts showing the full range of finishes and colours available, for selection by the Engineer.

C110 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of the work as the Engineer may reasonably require including elevations, large scale sections and proposed methods of fixing.

C115 SAMPLES: submit samples of each type of fitting in colours and finishes selected by the Engineer. Obtain approval of appearance and other characteristics before proceeding with manufacture or delivery.

C120 CONTROL SAMPLES: following approval of drawings and samples, prepare one of each type of purpose-made fitting as part of the quantity required for the project and obtain approval of appearance before proceeding with manufacture of remaining quantity.

## MATERIALS AND PRODUCTS

### X10:G COMPONENTS

G105 METAL, WOOD and other component parts of fittings including fastenings, fixings, treatments and finishings are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

G205 MARBLE OR GRANITE counter tops, fronts and the like are to be in accordance with the requirements of Section P21 of the Specification.

### X10:H SHELVING AND STORAGE FITTINGS

H105 SHELVING: shelving system comprising steel posts formed from 1 mm steel sheet with rows of slots vertically spaced on 38 mm centers. Both the adjustable and base shelves are formed of 1 mm steel and have backs approximately 125 mm high. Shelves are slotted for adjustable dividers on 25 mm centers. Base shelf front face is 38 mm high while adjustable shelf front face is 20 mm high. Finish shall be acrylic stove enameled paint.

Man: Kardex Systems, Inc**.** [http://www.kardex.com/]

or other equal and approved.

### X10:P COUNTERS, WORKTOPS AND BENCHES

P105 COUNTER UNITS: constructed from wood and wood based boards, faced on all exposed surfaces with wood veneer , and comprising counter tops, fronts and cupboard units with doors, drawers and shelves, and with hinges, sliding gear, locks, handles, drawer slides, accessories and fixings as required, all to be approved.

P510 BENCHES: frame constructed of cold rolled steel sections to BS EN 10219-2 finished with oil paint. Seats and backs are to be of approved mahogany hardwood with clear finish. Fixings are to be of cadmium plated or stainless steel.

X10:T SIGNS

T115 INTERNAL SIGNS for fixing to walls, doors and the like: polyester powder coated aluminium extruded sections and insert strips with applied vinyl legend. Refer to Section M22 of the Specification for door signage.

T205 EXTERNAL LETTERING: 4 mm thick solid bronze with polished finish, in Arabic and English characters of the types and sizes shown on the Drawings.

X10:X SUNDRY FITTINGS

X114 CORNER GUARD: surface mounted corner guard made of high impact vinyl / acrylic profile with continuous aluminium retainer and continuous shock cushion.

Man: Construction Specialities [http://www.c-sgroup.co.uk/ ]
Ref: Acrovyn surface mounted corner guard SM 20

Man: Balco Inc. [http://www.balcousa.com/]
Ref: Surface mounted corner guard CGS-5

or other equal and approved.

X122 WALL BUMPER / HANDRAIL: heavy duty impact bumper 38.1 x 139.7 mm manufactured of high-impact vinyl/acrylic extrusions, designed to absorb shock and resist mars and abrasion under impact.

Man: Construction Specialities [http://www.c-sgroup.co.uk/ ]
Ref: Acrovyn HRB-4C Handrail

or other equal and approved.

X406 TACKBOARDS: wall mounted units comprising fibre tack boards secured to blockboard backing, set in hardwood framing complete with accessories and fixings.

Man : ESA McIntosh Ltd [ http://www.esamcintosh.co.uk/ ]

or other equal and approved.

X615 DOOR MATS AND FRAMES: recessed foot grilles constructed of aluminium alloy 6063T52 treads which snap-lock together to comprise the overall grid length (traffic direction). Treads are to be set together in a rectangular 46 mm deep standard aluminium frame. Well is to be set, levelled and screeded to give a 44 mm flat and even base flush to the top of the frame flange. All materials shall be perforated between each tread for drainage, unless otherwise specified. Finish to be standard mill. All grids are pre assembled in maximum modular sizes of 3.66 m x 0.91m to fit within standard or custom frame sizes. Typical tread spacing is (38 mm) on centre. Add 25 mm to both width and length dimensions for frame clearance. Carpet treads shall be 100% solution dyed nylon, colour as selected by Engineer. Carpet fibre shall be fusion bonded to a rigid backing to eliminate fraying and to permit mechanical insertion in tread rail. All carpet shall be free of splices.

Man: Construction Specialities [http://www.c-sgroup.co.uk/ ]
Ref.: Pedigrid

or other equal and approved.

WORKMANSHIP

X10:1 GENERALLY

1151 COORDINATION: ensure manufacturer's standard details and fixing instructions are provided as necessary for co-ordination with related building elements and services.

1501 FABRICATING, MACHINING AND ASSEMBLING of fittings are, where relevant, to be in accordance with the requirements of Sections M11 and M12 of the Specification.

X10:2 INSTALLATION

2101 FIXING GENERALLY including storage and protection are, where relevant, to be in accordance with the requirements of Sections M11 and M12 of the Specification.

2201 KITCHEN FITTINGS AND CUPBOARD UNITS:

before fixing ensure that provision of all plumbing and services has been made, all plastering is finished and thoroughly dried out

reseal any sealed edges which have been cut; do not twist or rack; fix level and square with neat close fit to adjoining surfaces.

2601 SEALANT POINTING:

ensure that finishes to backgrounds are complete and surfaces to receive sealant are clean and dry

remove protective covering from fittings the minimum necessary to apply sealant

apply sealant in accordance with sealant manufacturer's recommendations to give a neat, smooth, watertight joint.

2901 COMPLETION: ensure that doors and drawers are accurately aligned and do not bind. Adjust as necessary to ensure smooth operation. Check, adjust and lubricate ironmongery as necessary to ensure correct functioning.

# X70 PREFABRICATED BUILDINGS

## GENERAL

### X70:A SCOPE

A105 SCOPE: this Section is for the specification of prefabricated buildings including kiosks and similar structures.

### X70:C SUBMITTALS

C105 PRODUCT DATA: submit manufacturer's product data and specifications for prefabricated buildings, including construction details, material descriptions, dimensions of individual components and profiles, together with charts showing the full range of finishes and colours available, for selection by the Engineer.

C110 DRAWINGS: provide co-ordination, fabrication and installation drawings and other information showing such details of the work as the Engineer may reasonably require including elevations, large scale sections and proposed methods of fixing.

C115 SAMPLES: submit samples of each type of material in colours and finishes selected by the Engineer. Obtain approval of appearance and other characteristics before proceeding with manufacture or delivery.

C120 CONTROL SAMPLES: following approval of drawings and samples, prepare one of each type of purpose-made fitting as part of the quantity required for the project and obtain approval of appearance before proceeding with manufacture of remaining quantity.

### X70:D PERFORMANCE REQUIREMENTS

D105 DESIGN LOADS: live loads; floor 2.4 kPa, roof 2.4 kPa, wind 160 km/h.

## MATERIALS AND PRODUCTS

### X70:X COMPONENTS

X105 CONTROL KIOSK: factory pre-fabricated, pre-assembled booth unit(s) comprising:

Structure: prefabricated steel building shall be single unit welded steel construction with 2.0 mm galvanised steel panels and tubing on the exterior and 1.3 mm galvanised steel interior panels. Unit to be shipped completely assembled. All welded joints ground smooth.

Base: 6.0 mm steel with pre-drilled, steel angle anchor clips to secure booth. Anchor bolts shall be galvanised steel for interior and stainless steel for exterior.

Door(s): top-suspended sliding aluminium type, fully weather-stripped. Include manufacturer’s standard lock, glazing and hardware.

Windows: aluminium construction and include glazing and all hardware as required. Provide sliding windows as shown on Drawings for ventilation and/or transaction purposes. Include insect screens in ventilation windows. Mill finish standard on active windows; clear anodised aluminium for fixed panes.

Glazing: clear tempered safety glass.

Finish: all steel surfaces shall be painted with rust-inhibitive epoxy primer. All exposed interior and exterior steel surfaces shall be painted with one finish coat of acrylic epoxy enamel. Colours of paint as selected by Engineer from manufacturer's standard range.

Canopy: shall be 2.0 mm galvanised steel and shall extend 80 mm beyond the side walls. Standard fascia height shall be 150 mm.

Roof: provide lifting ring welded and centred on the roof. Roof surface shall be 2.0 mm galvanised steel sheet with any seams continuously welded, caulked and weatherproofed. Roof sloped to rain downspout(s) or scupper for drainage.

Insulation: walls shall be insulated with 50 mm rigid fiberglass board, R-10. Roof structure fully insulated, R-17.4.

Work counter: one 460 mm minimum depth 2.0 mm thick painted same color as booth steel counter across width of booth. Include one 400 mm wide steel storage drawer. Counter shall be welded in place. Include one 300 mm electrical cord access hole.

Electrical: unit shall be delivered complete with all wiring required for fluorescent light, one duplex outlet, and 12-circuit breaker box. All wiring copper No. 12 minimum, enclosed in EMT. All wiring copper No. 12 minimum, enclosed in EMT. All fittings, wiring devices and fixtures UL listed. Ready for site connection. Electrical devices factory-installed within the prefabricated building shall be UL listed. Factory-installed wiring system shall bear UL Classification label certifying compliance with the current edition of the NFPA's National Electric Code.

Provide prefabricated booth with air conditioning unit of capacity to ensure an inside conditions of 24 deg and 50 % relative humidity at peak summer and winter ambient conditions.

Optional features: provide items available from manufacturer’s optional equipment list at direction of Engineer.

Man: Par-Kut International, Inc. [http://www.parkut.com/]
Man: Parking Booth Co., Inc [http://parkingboothco.com/]
Man: B.I.G. Enterprises Inc. [http://www.bigbooth.com/]

or other equal and approved.

## WORKMANSHIP

### X70:1 GENERALLY

1151 COORDINATION: ensure manufacturer's standard details and fixing instructions are provided as necessary for co-ordination with related building elements and services.

1501 GENERAL: install prefabricated buildings on flat and level concrete pad in accordance with the manufacturer's recommendations and placement drawings. Position units over utility stub-ups; verify building is level and anchor.

### X10:2 INSTALLATION

2101 FIXING GENERALLY including storage and protection are, where relevant, to be in accordance with the requirements of Sections M11 and M12 of the Specification.

2151 COMPLETION: ensure that doors and drawers are accurately aligned and do not bind. Adjust as necessary to ensure smooth operation. Check, adjust and lubricate ironmongery as necessary to ensure correct functioning.

# X80 TOILET AND BATH ACCESSORIES

## GENERAL

### X80:A SCOPE

A105 SCOPE: this Section is for the specification of toilet and bath accessories including unit mirrors, together with associated fixings and accessories.

### X80:C SUBMITTALS

C105 PRODUCT DATA: submit manufacturer's product data. Include construction details, material descriptions and thicknesses, dimensions, profiles, fastening and mounting methods, specified options, and finishes for each type of accessory specified.

C110 SAMPLES: submit full-size samples for each accessory item specified for the purpose of verifying design, operation, and finish requirements. Approved samples will be returned and may be used in the work.

C115 SETTING DRAWINGS: submit drawings for cut-outs required in other work; include templates, substrate preparation instructions, and directions for preparing cut-outs and installing anchoring devices.

C120 PRODUCT SCHEDULE: submit product schedule indicating types, quantities, sizes, and installation locations by room of each accessory required. In the Product Schedule, use designations indicated in the Toilet and Bath Accessory Schedule and room designations as indicated on Drawings.

C125 MAINTENANCE DATA: submit maintenance data for accessories, to be included in the operation and maintenance manuals specified in Division 1. Provide lists of replacement parts and service recommendations.

### X80:D QUALITY ASSURANCE

D105 SOURCE LIMITATIONS: unless otherwise specified or approved by the Engineer, provide products of same manufacturer for each type of accessory unit and for units exposed to view in same areas.

D115 PRODUCT OPTIONS: accessory requirements, including those for aesthetic effects, materials, finishes, dimensions, capacities and performance, are established by specific products indicated in the Toilet and Bath Accessory Schedule.

products of other manufacturers with equal characteristics, as judged solely by Engineer, may be provided subject to approval

do not modify aesthetic effects, as judged solely by Engineer, except with Engineer's approval. Where modifications are proposed, submit comprehensive explanatory and comparative data to Engineer for review.

## MATERIALS AND PRODUCTS

### X80:F COMPONENTS

F105 METAL component parts of fittings including fastenings, fixings, treatments and finishings, unless otherwise indicated are to be in accordance with the requirements of Sections M11 and M12 of the Specification.

F115 STAINLESS STEEL: ASTM A 666 Type 304, with satin finish, in 0.8-mm minimum nominal thickness, unless otherwise indicated.

F130 CHROMIUM PLATING: ASTM B 456, Service Condition SC 2 (moderate service), nickel plus chromium electro-deposited on base metal.

F135 MIRROR GLASS: as per the requirements of Section R11 of the Specification.

F145 FASTENERS, screws, bolts, and other devices are to be of same material as accessory unit, tamper and theft resistant when exposed, and of galvanized steel when concealed.

### X80:G FABRICATION

G105 GENERAL: one, maximum 38-mm-diameter, unobtrusive stamped manufacturer logo, as approved by Engineer, is permitted on exposed face of accessories. On interior surface not exposed to view or back surface of each accessory, provide printed, waterproof label or stamped nameplate indicating manufacturer's name and product model number.

G110 SURFACE-MOUNTED TOILET ACCESSORIES: unless otherwise indicated, fabricate units with tight seams and joints, and exposed edges rolled. Hang doors and access panels with continuous stainless-steel hinge. Provide concealed anchorage where possible.

G120 FRAMED GLASS-MIRROR UNITS: fabricate frames for glass-mirror units to accommodate glass edge protection material. Provide mirror backing and support system that permits rigid, tamper-resistant glass installation and prevents moisture accumulation. Provide galvanised steel backing sheet, not less than 0.85 mm and full mirror size, with non-absorptive filler material. Corrugated cardboard is not an acceptable filler material.

G125 KEYS: provide universal keys for internal access to accessories for servicing and re-supplying. Provide and deliver a minimum of six keys to Engineer.

## WORKMANSHIP

### X80:1 GENERALLY

1151 COORDINATION: ensure manufacturer's standard details and fixing instructions are provided as necessary for co-ordination with related building elements and services.

1501 FABRICATING, MACHINING AND ASSEMBLING of fittings are, where relevant, to be in accordance with the requirements of Sections M11 and M12 of the Specification.

### X80:2 INSTALLATION

2101 FIXING GENERALLY including storage and protection are, where relevant, to be in accordance with the requirements of Sections M11 and M12 of the Specification.

2105 INSTALL ACCESSORIES according to manufacturers' written instructions, using fasteners appropriate to substrate indicated and recommended by unit manufacturer. Install units level, plumb, and firmly anchored in locations and at heights indicated.

2110 SECURE MIRRORS to walls in concealed, tamper-resistant manner with special hangers, toggle bolts, or screws. Set units level, plumb, and square at locations indicated, according to manufacturer's written instructions for substrate indicated.

2115 INSTALL GRAB BARS to withstand a downward load of at least 1112 N, when tested according to method in ASTM F 446.

## X80:3 ADJUSTING AND CLEANING

3105 ADJUST ACCESSORIES for unencumbered, smooth operation and verify that mechanisms function properly. Replace damaged or defective items.

3110 REMOVE temporary labels and protective coatings.

3115 CLEAN and polish exposed surfaces according to manufacturer's written recommendations.

## X80:4 TOILET AND BATH ACCESSORY SCHEDULE

4105 GENERAL: provide the following toilet accessories by one of the manufacturers listed or any other approved equal:

A. Paper Towel Dispenser

Surface-Mounted Type: type 304 stainless steel, satin finish. Size minimum 200 C-fold or 275 multifold paper towels without special adapters; with hinged front equipped with tumbler lockset; and with refill indicator that are pierced slots at side or front.

Man: Bobric

or any other equal and approved

B. Toilet Tissue Holder
Surface-Mounted Type.

Man: Bobric

C. Napkin Disposal

Surface-Mounted Type

Surface-Mounted Sanitary Napkin Disposal, with chrome plated.

Man: Bobric
Ref: B-270

or any other equal and approved

D. Liquid Soap Dispenser

Surface-Mounted Type: shall be chrome plated, Sensor Operated Wall-mounted Liquid Soap Dispenser.

Man: Sloan www.sloanvalve.com
Ref: SJS-1050

E. Liquid Soap Dispenser

Surface-Mounted Type: wall mounted liquid soap dispenser piston and spout assembly shall be chrome plated with bright polished finished.

Man: Grohe AG
Ref: 40373

F. Grab Bar

Surface-Mounted Type.

Surface-Mounted Type: polished stainless steel exposed mounting 455 mm long, 38 mm diameter

Man: Kohler

or any other equal and approved

G. Mirror Unit

Surface-Mounted Type.

Surface-Mounted Type: stainless steel, channel-framed mirror. Fabricate frame from Standard satin or bright finish with square corners mitered to hairline joints and mechanically interlocked.

Man: Bobric

or any other equal and approved

H. Warm-Air Hand Dryer

Surface-Mounted Type:

Electric hand dryer mounted 1092 mm above FFL to bottom in men's washrooms and 1016 mm AFFL to bottom in women's washrooms (one per washroom).

Man: Dyson Airblade

or any other equal and approved

# Y21 BASES TO PAVINGS

## GENERAL

### Y21:A SCOPE

A105 SCOPE: this Section includes materials for bases and sub bases and for hard landscaping.

### Y21:B RELATED SECTIONS

B110 OTHER SECTIONS of the Specification containing requirements that relate to this Section include but are not necessarily limited to the following:

Section Y22 "Kerbs, Edgings and Channels"

Section Y23 "Block and Slab Pavings"

### Y21:C SUBMITTALS

C110 SAMPLES: before placing orders submit for approval, representative samples of each type and composition of base and sub-base materials indicated. Ensure that delivered materials match approved samples.

C120 TESTING: for each type of base and sub-base materials proposed to be used, submit supplier's certified results for tests indicated:

### Y21:D QUALITY ASSURANCE

D110 SOURCE LIMITATIONS: obtain each type of base and sub-base materials, and setting material; from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

MATERIALS AND PRODUCTS

Y21:Y SUB-BASE AND BASE MATERIALS

Y105 GRANULAR MATERIAL for Sub-base and Base courses shall be hard and durable, free from harmful matter, dirt and organic impurities and shall consist of the following:

Sub-base shall consist of granular material, screened from crushed or natural gravel to the specified size and gradation.

Base course shall consist of crushed stone or gravel to the specified sizes and gradation.

Y205 GRANULAR MATERIAL: shall conform to the following gradation requirements:

| Sieve Designation | Percent by weight passing | |
|---|---|---|
| | Sub-base | Base |
| 50 00 mm (2 inch) | 100 | 100 |
| 37.50 mm (1-1/2 inch) | - | 95-100 |
| 25 00 mm (1 inch) | 75-95 | 70-95 |
| 19 00 mm (3/4 inch) | - | 55-85 |
| 9.50 mm (3/8 inch) | 40-75 | 40-70 |
| 4.75 mm (No.4) | 30-60 | 30-60 |
| 2.00 mm (No.10) | 20-45 | 20-45 |
| 0.425 mm (No.40) | 15-30 | 15-30 |
| 0.075 mm (No.200) | 5-20 | 5-10 |

Y305 GRANULAR MATERIAL: shall conform to the following requirements:

| Test / Designation | Sub-base | Base |
|---|---|---|
| Clay Content AASHTO T 88 | Max 5% | Max 5% |
| Fines Content AASHTO T 27 | - | Passing No. 200 shall be less than half passing No.40 |
| Los Angeles abrasion AASHTO T 96 | < 50% | < 45% |
| CBR ASTM D 1883 (4 day soaked sample compacted at 100% Modified proctor) | ≥ 30% | ≥ 80% |
| Soundness AASHTO T 104 (Max. loss in weight after 5 cycles) | Sodium 12% Magnesium 18% | Sodium 12% Magnesium 18% |
| Fine aggregate AASHTO T 89, T 90 | For passing No.40 LL ≤ 30%, PI ≤ 6% | For passing No.40 LL ≤ 25%, PI ≤ 6% |

Y405 SAMPLE OF GRANULAR MATERIAL: shall be obtained and tested in approved Laboratories and shall satisfy all specified test requirements prior to approval and stockpiling.

Y505 IN SITU CONCRETE: materials, concrete mix, reinforcement, formwork and designed joints are to be in accordance with the requirements of Division E of the Specification.

## WORKMANSHIP

### Y21:1 GENERALLY

1101 EXCAVATION AND EARTHWORK are to be in accordance with the requirements of Division 60 of the Specification.

1201 CONCRETE WORK is to be in accordance with the requirements of Division E of the Specification.

### Y21:2 PREPARATION OF SUBGRADE

2101 COMPACTION OF SUBGRADE:

ensure that subgrade is dry and clean prior to compaction

defer final excavation to formation level until immediately before compaction of subgrade

soft spots must be brought to the attention of the Engineer and instructions obtained before proceeding

subgrade must be relatively dry at time of compaction

where use of roller is impracticable use suitable mechanical rammer

where local excavation and backfilling has taken place make additional passes of roller.

## Y21:3 PLACING GRANULAR MATERIAL

3101 GENERALLY:

ensure that subgrade is free from loose soil, rubbish and standing water. Clean and prepare subgrade prior to spreading of Sub-base or Base courses

take necessary precautions to ensure stability of adjacent structures

thoroughly mix aggregates and water to uniform moisture content and place, spread and compact materials on prepared subgrade

place and compact material against structures, membranes or buried services in a sequence and manner, which will ensure stability and avoid damage.

3201 GRANULAR SUB-BASE AND BASE FOR VEHICULAR AREAS: spread granular Sub-base on prepared subgrade and granular Base on prepared Sub-base in uniform layers not exceeding in thickness, before compaction, the following limits:

Sub-base: 250 mm

Base: 200 mm

Compact each layer by approved roller to the following density requirements:

Sub-base: 100% of maximum density, AASHTO T 180

Base: 100% of maximum density, AASHTO T 180

3251 GRANULAR SUB-BASES FOR PEDESTRIAN AREAS: spread and level and, as soon as possible thereafter, compact with approved roller weighing not less than 2.5 tonnes or other approved plant.

3301 TOLERANCES: fully compacted and completed subgrade, Sub-base and Base courses shall conform to lines, levels and cross-sections shown on Drawings. Maximum permissible deviations from required levels, falls and cambers are to be as follows:

| | | |
|---|---|---|
| subgrade: | vehicular areas | +/-25 mm |
| | pedestrian areas | +/-20 mm |
| Sub-base: | vehicular areas | +/-20 mm |
| | pedestrian areas | +/-12 mm. |
| Base: | vehicular areas | +/-15 mm |

Remove defective areas and sections and replace to correct tolerances. Maintain finished course in good condition until succeeding layer is placed.

3401 TESTING: carry out in-situ testing as directed by the Engineer and in accordance with the Project requirements.

3501 COMPACTION FOR SUB-BASE AND BASE: shall be tested in accordance with AASHTO T 191 or AASHTO T 205.

3601 BLINDING: surfaces to receive paving are to have sufficient sand, fine gravel or other approved fine material applied to provide a close and smooth surface.

3701 PROTECTION:

overlay Sub-bases and Base courses with subsequent layers as soon as practicable

prevent damage to subgrade, Sub-base and Base courses from construction traffic, construction operations and inclement weather.

# Y22 KERBS, EDGINGS AND CHANNELS

## GENERAL

### Y22:A SCOPE

A105 SCOPE: this Section includes the following:

Kerbs
Edgings
Channels

### Y22:B RELATED SECTIONS

B110 OTHER SECTIONS of the Specification containing requirements that relate to this Section include but are not necessarily limited to the following:

Section G21 "Making Mortar"

Section J31 "Movement Joints"

Section P12 "Screeds and Toppings"

Section P21 "Rigid Floor and Wall Tiling and Slabs"

Section Y21 "Bases to Pavings"

Section Y23 "Block and Slab Pavings"

### Y22:C SUBMITTALS

C105 SHOP DRAWINGS: submit shop drawings showing kerbs, edgings and channel installations, including but not necessarily limited to the following:

plans and elevations showing locations, layouts and patterns

locations, widths and details of expansion, contraction, control and isolation joints, and division strips in tile/slab substrates and finished tile/slab surfaces

locations and details of waterproofing underlayments.

C110 SAMPLES: before placing orders submit for approval and selection of colours, finishes and textures, representative samples of each type and composition of pavers indicated, together with associated trims and accessories. Ensure that delivered materials match approved samples.

C115 CONTROL SAMPLES: in approved locations complete sample areas of not less than 10 m of each type of kerbs, edgings and channels as part of the permanent work. Obtain approval of appearance before proceeding.

C120 TESTING: for each type of kerbs, edgings and channels proposed to be used, submit supplier's certified results for following tests:

weight per unit of volume

absorption coefficient

compression breaking load

compression breaking load after freezing

ultimate tensile strength.

C125 INSTALLER CERTIFICATES: signed by product manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install his products.

C130 INSTALLER EXPERIENCE: list of five projects (minimum) of a similar nature carried out successfully by the installer with the same product endorsed by the manufacturer’s representative.

Y22:D QUALITY ASSURANCE

D105 INSTALLER QUALIFICATIONS: a qualified firm specializing in performing the work of this Section with minimum three years documented experience and that is approved, authorized, or licensed by the product manufacturer to install his product and that is eligible to receive manufacturer's warranty. Include project names and addresses, names and addresses of Engineers and Owners, and other relevant information.

D110 SOURCE LIMITATIONS: obtain each type of kerbs, edgings and channels, joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

D120 MOCKUPS: before installing kerbs, edgings and channels, build mockups for each form and pattern required to verify selections made under sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for the completed Work, including same base construction, special features for expansion joints, and contiguous work as indicated:

build mockups in the location and of the size indicated or, if not indicated, as directed by Engineer

demonstrate the proposed range of aesthetic effects and workmanship

obtain Engineer's approval of mockups before starting installation

maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work

approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

## MATERIALS AND PRODUCTS

### Y22:E GENERALLY

E105 KERBS, EDGINGS AND CHANNELS: manufacturing tolerances shall be 3mm in any one dimension. End and edge faces shall be perpendicular to the base. Bullnoses and curved faces shall be of constant radius with a smooth change from radius to straight face.

E205 STRAIGHT UNITS: unless otherwise approved are to be generally 0.50 m in length. Where straight units are installed along horizontal curves of more than 12 m radius, use reduced length units as directed.

E210 RADIUS UNITS: unless otherwise approved, for horizontal curves of radii 12 m or less, use units manufactured to the radius indicated.

E305 SURFACES: that will be exposed to view after installation, shall be true and even, with a dense finish of uniform texture and colour, free from cracks, holes, fins, staining or other blemishes or defects.

E405 SAMPLES: before placing orders submit for approval, representative samples of each type of kerb, edging and channel unit proposed to be used together with manufacturer's certificates and details of manufacturing method and materials used. Ensure that delivered materials match approved samples. Notwithstanding approval of samples, the Engineer reserves the right to reject any units delivered to the site which in his opinion do not conform to the required standards.

## Y22:F PRECAST CONCRETE UNITS

F105 KERBS, EDGINGS AND CHANNELS: precast concrete units conforming to the general requirements of BS 7263-1 & 3, obtained from an approved manufacturer and to the cross sectional shapes and sizes shown on the Drawings, including radius, transitional and special units as indicated and required:

| | | |
|---|---|---|
| colour | : | natural, to approval |
| exposed finish | : | plain face |
| mortar joints | : | narrow |

F205 MANUFACTURE: unless otherwise approved, precast units are to be Portland cement concrete Class B in accordance with the requirements of Division E of the Specification, cast in steel moulds under conditions of controlled temperature and humidity, steam cured until the concrete has attained specified 28-day strength.

F210 SURFACES: that will not be exposed to view after installation shall have all fins and irregular projections removed and all cavities, minor honeycombing and other defects made good with mortar after the units have been saturated with water for at least 3 hours.

G115 PRECAST CONCRETE KERBS: precast concrete units made from normal-weight aggregate conforming to the general requirements of BS 7263-1 & 3, obtained from an approved manufacturer and to the cross sectional shapes and sizes shown on the Drawings, including radius, transitional and special units as indicated and required:

| | |
|---|---|
| Colour: | natural, to approval |
| Exposed finish: | plain face |
| Mortar joints: | narrow |

## Y22:Y FOUNDATION AND BEDDING MATERIALS

Y105 FOUNDATIONS AND HAUNCHING: plain, concrete refer to Division E of the Specification.

Y205 MORTAR FOR BEDDING AND JOINTING: sulphate-resisting Portland cement and sand 1:3 in accordance with the requirements of Section G21 of the Specification. Sand for mortar to BS 882, grading M or F.

WORKMANSHIP

Y22:1 GENERALLY

1101 QUALITY OF WORK: conform to the applicable requirements of BS 7533-4, otherwise:

handle, store and install units in accordance with manufacturer's recommendations

do not use damaged or disfigured units; cut neatly and accurately with a masonry saw and without spalling to give neat junctions

keep exposed faces of units clean and free from concrete and mortar droppings.

1201 INCLEMENT WEATHER: protect foundations, bedding and haunching against rapid drying by sun and wind.

1301 CHANNELS: set out to even gradient to ensure no ponding or backfall. Lowest points of channels are to be 6 mm above drainage outlets.

1351 RADIUS KERBS, EDGINGS AND CHANNELS are to be used for radii of 12 m or less.

1401 ACCURACY: maximum deviations:

| | |
|---|---|
| level | : +/-6 mm |
| horizontal and vertical alignment | : 3 mm in any 3 m. |

Y22:2 LAYING

2101 KERBS, EDGINGS AND CHANNELS: bed units in mortar, true to line and level on accurately cast foundations and secure with continuous haunching of concrete; allow bedding to set before placing haunching; bed thickness: 10 mm minimum to 40 mm maximum

2201 NARROW MORTAR JOINTS: butter ends of units with bedding mortar as laying proceeds to completely fill joints. Tightly butt to a thickness of 3 mm, clean off surplus mortar immediately and trowel to a neat flush profile.

2301 TOOLED MORTAR JOINTS: butter ends of units with bedding mortar as laying proceeds to completely fill joints to thickness of 6 mm. Tool to neat flush profile.

2401 COLOURED MORTAR JOINTS: butter ends of units with bedding mortar as laying proceeds to completely fill joints to thickness of 6 mm. Rake out joints to a depth of 10 mm and point with approved matching colour pigmented mortar. Tool to neat flush profile.

# Y23 BLOCK AND SLAB PAVINGS

## GENERAL

### Y23:A SCOPE

A105 SCOPE: this Section includes the following:

Brick pavers set in aggregate setting bed.

Brick pavers set in mortar setting bed.

Concrete pavers set in aggregate setting bed.

Concrete pavers set in mortar setting bed.

Rough-stone pavers set in mortar setting bed.

Precast concrete kerbs and edges for unit pavers.

### Y23:B RELATED SECTIONS

B110 OTHER SECTIONS of the Specification containing requirements that relate to this Section include but are not necessarily limited to the following:

Section G21 "Making Mortar"

Section J11 "Bituminous Membrane Roofing" for specification for waterproofing and protection board under plaza deck pavers.

Section J31 "Movement Joints"

Section P12 "Screeds and Toppings"

Section P21 "Rigid Floor and Wall Tiling and Slabs"

Section Y21 "Bases to Pavings"

### Y23:C SUBMITTALS

C105 SHOP DRAWINGS: submit shop drawings showing paver installations, including but not necessarily limited to the following:

plans and elevations showing locations, layouts and patterns

locations, widths and details of expansion, contraction, control and isolation joints, and division strips in tile/slab substrates and finished tile/slab surfaces

locations and details of waterproofing underlayments.

C110 SAMPLES: before placing orders submit for approval and selection of colours, finishes and textures, representative samples of each type, dimensions and composition of pavers indicated, together with associated trims and accessories. Ensure that delivered materials match approved samples.

C115 CONTROL SAMPLES: in approved locations complete sample areas of not less than 10 m2 of each type of block and slab paving as part of the permanent work. Obtain approval of appearance before proceeding.

C120 TESTING: for each type of pavers proposed to be used, submit supplier's certified results for following tests:

weight per unit of volume

absorption coefficient

compression breaking load

compression breaking load after freezing

ultimate tensile strength.

C125 INSTALLER CERTIFICATES: provide signed certificates by product manufacturer certifying that Installer is approved, authorized, or licensed by manufacturer to install his products.

C130 INSTALLER EXPERIENCE: provide a list of five projects (minimum) of a similar nature carried out successfully by the installer with the same product endorsed by the manufacturer's representative.

Y23D: QUALITY ASSURANCE

D105 INSTALLER QUALIFICATIONS: a qualified firm specializing in performing the work of this Section with minimum three years documented experience and that is approved, authorized, or licensed by the product manufacturer to install his product and that is eligible to receive manufacturer's warranty. Include project names and addresses, names and addresses of Engineers and Owners, and other relevant information.

D110 SOURCE LIMITATIONS: obtain each type of unit paver, joint material, and setting material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

D120 MOCKUPS: before installing unit pavers, build mockups for each form and pattern of pavers required to verify selections made under sample submittals and to demonstrate aesthetic effects and qualities of materials and execution. Build mockups to comply with the following requirements, using materials indicated for the completed Work, including same base construction, special features for expansion joints, and contiguous work as indicated:

build mockups in the location and of the size indicated or, if not indicated, as directed by the Engineer

demonstrate the proposed range of aesthetic effects and workmanship

obtain the Engineer's approval of mockups before starting paver installation

maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work

approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

D130 PRELIMINARY TRIALS FOR CEMENT BOUND MATERIAL:

At least 10 days before the start of the main cement bound material works a trial area of at least 250 m2 shall be laid to asses the suitability of the proposed materials, mix proportions, mixing, laying, compaction plant and construction procedures.

When applicable the area shall include one longitudinal and one transverse construction joint. The location and area of the trial shall be subject to the approval of the Engineer.

The rate of testing for the trial area shall not be less than that required in this section of the specification.

The trial area will only be accepted for main construction in the Permanent Works if it complies with the Specification.

The main construction in the Permanent Works shall not start until the trial has been approved by the Engineer.

After approval has been given, the materials, mix proportions, mixing, laying compaction plant and construction procedures shall not be changed without the approval of the Engineer who may require the Contractor to lay a further trial area to assess the suitability of the proposed changes.

## MATERIALS AND PRODUCTS

### Y23:G BLOCK PAVING

G305 INTERLOCKING CONCRETE BLOCKS: to BS 6717 [ASTM C 936], precast concrete interlocking block pavers, obtained from an approved manufacturer and to the shapes, sizes, colours, finishes and patterns shown on the Drawings.

### Y23:S SLAB PAVING

S355 PRECAST CONCRETE SLABS: to BS 7263-1 & 3, hydraulically pressed precast concrete paving slabs obtained from an approved manufacturer and to the shapes, sizes, colours, finishes and patterns shown on the Drawings.

### Y23:X ACCESSORIES

X105 MOVEMENT JOINTS: as per section J31.

X110 GEOTEXTILE: woven or nonwoven geotextile manufactured from polyester or polypropylene fibers, with a permeability rating 10 times greater than that of soil on which paving is founded and an apparent opening size small enough to prevent passage of fines from leveling course into graded aggregate of base course below.

X115 PRECAST CONCRETE KERBS: precast concrete units made conforming to the general requirements of BS 7263-1 and 3, obtained from an approved manufacturer and to the cross sectional shapes and sizes shown on the Drawings, including radius, transitional and special units as indicated and required:

| | | |
|---|---|---|
| colour | : | natural, to approval |
| exposed finish | : | plain face |
| mortar joints | : | narrow |

X205 TREE GRILLES: as indicated on the Drawings.

## Y23:Y BEDDING AND JOINTING MATERIALS

Y105 CEMENT-SAND MORTAR for bedding tiles and slabs is to be to the requirements of Section G21 of the Specification and unless otherwise specified, is to comprise:

ordinary portland cement to BS EN 197-1, except for marble types that may stain as a consequence of use, substitute white portland cement to BS EN 197-1

sand for walls to BS EN13139

sand for floors to BS 882, Table 5, grading limit M, but where fine sand is specified grading limit F

submit mix for approval to give a 28 day compressive strength of not less than 5 MPa. Minimum cement sand ratio should not be less than 1:3-4 by volume.

Y115 MORTAR: factory premixed mortar to BS 4721 and to be to the requirements of Section G21 of the Specification. Compressive strength at 28 days shall not be less than 5 Mpa.

Y205 BEDDING SAND: clean sharp sand, free from deleterious salts and contaminants with clay, silt and fine dust content of not more than 3% by mass. Obtain from a single source, consistently graded according to the requirements of BS 7533-3, Table 2:

do not use sand that will stain paving blocks

maintain bedding sand at even moisture content which will give maximum compaction during block laying.

Y305 CEMENT BOUND MATERIAL:

Cement bound material shall be mixed in the plant using the mass method of batching.

Moisture content to suit the requirements for strength surface, level regularity and finish.

Minimum compaction: 95% of cube strength

Plant-mixed cement bound material shall, when mixed, be removed at once from the mixer, transported directly to the point where it is to be laid and protected from the weather both during transit from the mixer to the laying site and whilst awaiting tipping.

Where the mix-in plant method is used and materials are batched by mass, the materials shall be batched and mixed in compliance with BS 5328: Part 3. Where continuous mixers are used and materials are batched by mass, the continuous mixers shall comply with Table 5 of BS 1035: 1974 when tested in accordance with BS 3963.

CBM shall be made from gravel sand, a washed or processed granular material, crushed rock, all in aggregate, blastfurnace slag or any combination of these. The material shall fall within the grading limits of Table 1 below.

The material shall have 10 % fines value of 50 kN or more when tested in accordance with BS 812: Part 111 with samples in a soaked condition.

The average compressive strength determined after immersion in water of five test specimens of CBM shall not be less than 80% of the average compressive strength of five control specimens when subjected to the test procedure described in BS 1924: Part 2: 1990, clause 4.3. After the 7 days immersion period the specimen shall not show any signs of cracking or swelling.

Table 1: AGGREGATE FOR CEMENT - BOUND BASE COURSE

| Sieve Size | Percentage by Weight Passing Sieves |
|---|---|
| 2.0 in. (50 mm) | 100 |
| 1.5 in. (37.5 mm) | 95-100 |
| 0.75 in (20 mm) | 45-80 |
| No. 4 (5 mm) | 25-50 |
| No. 30 (600 micro-m) | 8-30 |
| No. 100 (150 micro-m) | 0-8* |
| No. 200 (75 micro-m) | 0-5 |

*0-10 for crushed rock fines

Cement content:

Prior to start of work, laboratory tests of materials submitted by the Contractor shall be made to determine the quantity of cement required in the mix. The cement content for construction shall be that at which the mix develops an average 7-day cylinder compressive strength of at least 8,000 KPa and no individual compressive strength results is lower than 5,200 KPa. The testing procedure shall be as follows: mould and cure specimens in accordance with ASTM D 560; soak specimens in water for 4 hours; cap and break specimens in compression in accordance with ASTM D 1633.

## Y23:V SURFACE FINISHES

V150 POLYURETHANE CONCRETE SEALER: solvent based polyurethane penetrating sealer providing abrasion, chemical resistant, colourless, dustproof and sealed surface. When applied over concrete floors, it shall seal the surface give adequate protection against chloride attack and carbonation.

Man: Tremco Incorporated

Man: Weber &Broutin
Ref: Hardac polyurethane sealer

Man: Master Builders Technologies / Degussa

or other equal and approved.

## WORKMANSHIP

## Y23:1 GENERALLY

1101 QUALITY OF WORK: conform to the requirements of BS 7533-3 & 4 as applicable, otherwise:

carry out work and use materials in accordance with manufacturer's recommendations

ensure that sub-bases are suitably accurate and to specified gradients before laying paving

do not use damaged or disfigured paving units; cut neatly and accurately with a masonry saw to give neat junctions at edgings, changes in pattern and adjoining finishes

select blocks and slabs vertically from at least three separate stacks in rotation, or as required to avoid colour banding in the finished paving

lines and levels of finished surface are to be smooth and even with regular falls to prevent ponding

finished paving is to have an even overall appearance with even joint widths and free of mortar and sand stains.

1301 INCLEMENT WEATHER: adequately protect paving with mortar joints and/or mortar bedding from rapid drying out and saturation until mortar has hardened.

1401 ACCEPTANCE OF BASE: before starting work ensure that:

base is sound, clean and suitably close textured

levels and falls of base are as detailed, within specified tolerance +/-12 mm

drainage outlets are within +0 to -10 mm of required finished level.

1501 LEVELS OF PAVING: permissible deviation from specified levels is to be +/-6 mm generally. Paving is to be set 6 mm above drainage outlets and 3 mm above kerbs to allow for settlement.

1551 REGULARITY: sudden irregularities not permitted. Where appropriate in relation to geometry of surface, the variation in gap under a 3 m straight edge placed anywhere on surface is to be not more than 10 mm. Difference in level between adjacent paving units is not to be more than 2 mm.

1601 SETTING OUT of paving and related features is to be as shown on the Drawings.

1701 THICKNESSES of mortar beds are to be as shown on the Drawings.

Y23:2 LAYING PAVING

2101 MORTAR BEDDED BLOCK PAVING:

spread and level a bed of dry mortar; individually lay and hammer down the blocks so that tops are level, leaving joints open

carefully and thoroughly fill joints flush with surface of blocks with mortar of stiff plastic consistency and finish neatly; clean any mortar from face of blocks before it sets.

2121 JOINT WIDTHS in stone block paving are to be nominal 10 mm.

2151 INTERLOCKING BLOCK PAVING: unless otherwise specified:

do not commence paving until adjacent kerbs, edgings and channels have been are installed and sufficiently matured

lay blocks to required pattern on sand bed and thoroughly compact with a vibrating plate compactor as the work proceeds, but after infilling at restrained edges; apply

the same compacting effort over all areas, avoiding damage to edges and adjacent work

do not compact within 1 m of a working face

do not leave uncompacted areas of paving at the end of working periods, except within 1 m of unrestrained edges

check compacted paving initially and at frequent internals to ensure surface levels are correct; lift blocks, adjust bedding and relay paving as necessary

brush dry bedding sand into joints, re-vibrate surfaces and repeat as required to completely fill joints.

2201 COBBLE PAVING:

spread and level a bed of stiff plastic mortar; press cobbles on end into bed, tightly butted shoulder to shoulder and hammer down so that tops are level

thoroughly fill joints with dry mortar mix and brush off to leave tops of cobbles exposed to approval.

2301 SLAB PAVING:

bed on mortar so that rocking of slabs does not occur or develop

when surface of paving is dry, carefully and thoroughly fill joints with semi-dry mortar mix coloured to approval using a proper pointing tool; clean any mortar from face of pavings before it sets

immediately after completing joints, cover paving with polythene sheeting for not less than 3 days.

2351 JOINT WIDTHS in stone slab paving are to be nominal 6 mm.

2361 JOINT WIDTHS in concrete slab paving are to be nominal 3 mm.

2401 PROTECTION FROM TRAFFIC: pavings bedded on mortar must be kept free from pedestrian traffic for 4 days and vehicular traffic for 10 days after laying.

## Y23:3 FIXING OF ACCESSORIES

### 3101 MOVEMENT JOINTS:

build in joint filler as work proceeds, extending through paving, bedding and base and position accurately at recommended distance from surface of paving

preparation of joints, depth of sealant and application are to be strictly as sealant manufacturer's recommendations

joints must be thoroughly clean, dry and free from oil; mask edges of joint with tape before priming and remove immediately after sealing

apply sealant to exposed faces of units, ensuring maximum adhesion to sides of joint and a neat, smooth, clean finish.

## Y23:4 CONSTRUCTION OF CEMENT BOUND MATERIAL

### 4101 LAYING:

All cement bound material shall be placed and spread evenly in such manner as to prevent segregation and drying.

Spreading shall be undertaken either concurrently with placing or without delay.

Road base cement bound material shall be spread using a paving machine or a spreader box approved by the Engineer and operated with a mechanism which levels off the cement bound material to an even depth.

Cement bound material shall be spread in one layer so that after compaction the total thickness is as specified.

At longitudinal or transverse construction joints, unless vertical forms are used, the edge of compacted cement bound material shall be cut back to a vertical face where the correct thickness of properly compacted cement bound material has been obtained.

### 4105 COMPACTING:

Compaction shall be carried out immediately after the cement bound material has been spread and in such a manner as to prevent segregation.

Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse construction joints.

Compaction shall be carried out in compliance with requirements of Section A.1 above and be completed within 2 hours of the addition of the cement. The 2 hours may be varied at the discretion of the Engineer if the preliminary trial indicates that this is necessary or appropriate. After compaction has been completed, compacting equipment shall not bear on cement bound material for the duration of the curing period.

The surface of any layer of cement bound material shall on completion of compaction and immediately before overlaying, be well closed, free from movement under compaction plant and from ridges, cracks, loose material, pot holes, ruts or other defects. All loose, segregated or otherwise defective areas shall be removed to the full thickness of the layer and new cement bound material laid and compacted.

4110 CURING:

Immediately on completion of compaction, the surface of cement bound road bases shall be cured for a minimum period of 7 days (unless the Engineer agrees to a shorter period) by one of the following methods:

Covering with impermeable sheeting with joints overlapping at least 300 mm and set to prohibit egress of moisture. The sheeting shall be removed at the end of the curing period.

Bituminous spraying which shall only be applied when there is no visible water. When the cement bound material is likely to be exposed to high temperatures and solar radiation, the bituminous spray shall be blinded with light colored material.

Spraying with a curing compound.

Spraying with an approved plastic film which when hardened shall be removed before applying any other pavement layer.

4115 TESTING OF CEMENT BOUND MATERIALS:

Samples shall be provided in accordance with BS 1924: Part 1: 1990 Clause 5 from the laid cement bound material before compaction. One group of five samples shall be provided from five locations equally spaced along a diagonal that bisects each 800 $mm^2$ or part thereof laid each day. The number of groups may be increased if required by the Engineer.

One 150 mm cube shall be made from each sample taken in accordance with sub - clause H1 of this clause. The cubes shall be made in accordance with BS 1924: Part 2: 1990, without further mixing of the material and within 2 hours of the addition of the cement. Cubes shall be cured and tested in accordance with Table 6.6.

To determine the wet density of cubes the mould shall be weighed prior to making the cube and the mass recorded. Immediately after completion on of compaction, the cube and mould shall be weighed and the mass recorded. These masses together with the nominal volume of the mould shall be used to derive the wet density of the cube.

The in-situ wet density of a layer of cement bound material shall be taken as the average of the wet densities at five locations equally spaced along a diagonal that bisects each 800 m 2 or part thereof laid each day. The wet density at each location shall be the average of two readings obtained using a nuclear density gauge complying with BS 1377: Part 9. The two readings shall be taken at 180 degrees to each other using the same source rod hole. The source rod shall be lowered to within 25mm of the bottom surface of the layer. Readings shall be taken within two hours of completing final compaction.

# Y31 PAVEMENT MARKINGS

## GENERAL

### Y31:A SUMMARY

A101 These Works consist of the furnishing and application of markings to pavements for guidance, control and safety of vehicular and pedestrian traffic, as shown on the Drawings.

## MATERIALS AND PRODUCTS

### Y31:U REFLECTORIZED PAINT (RP)

U101 REFLECTORIZED PAINT: shall consist of a mixture of binder, colour pigment, and filler specifically compounded for cold application and adhesion to finished pavements. Paint shall be reflectorized by adding reflective glass spheres before the film dries or sets.

U105 REFLECTORIZED PAINT: to AASHTO M248, colour white or yellow as indicated on Drawings. Surface application glass spheres shall conform to AASHTO M247, Type 1.

### Y31:V PAVEMENT MARKING PAINT (MP)

V105 PAVEMENT MARKING PAINT: to BS 6044, colour white, to give minimum luminance factor of 75.

## WORKMANSHIP

### Y31:1 GENERALLY

1010 EQUIPMENT for pavement marking shall consist of approved types of motorized equipment or manually operated equipment according to the paint manufacturer recommendations for the type of markings being applied.

1205 SETTING OUT: set out all control points necessary for locating and accurately establishing paint lines and markings shown on Drawings.

1210 SURFACE PREPARATION: thoroughly clean pavement surfaces to remove dirt, grease, oil, moisture, loose or unsound layers, and any other material which could adversely affect adhesion of the paint. Obtain approval before proceeding with painting.

1305 APPLICATION of paint to pavement surfaces shall be carried out in accordance with the paint and equipment manufacturer's recommendations and instruction, or as otherwise directed by the Engineer.

1310 APPLICATION: do not proceed when:

there is moisture on the pavement surface or the air is misty

the surface temperature of the pavement is below 10 deg. C

wind or other conditions may cause a film of dust to be deposited on the surface, or

in other conditions that, in the opinion of the Engineer, could displace, damage, or adversely affect the bonding of the material to the pavement surface.

Any markings damaged due to water or rain within 30 minutes after application, shall be removed and replaced by the Contractor at his own expense.

1405 PROTECTION: prevent traffic from crossing wet paint lines using barricades or other means. Any areas of paint which are damaged before the paint has cured, shall be repaired and remedied by the Contractor at his own expense.

1505 TOLERANCES of +12 mm or -3 mm to specified line widths will be allowed, provided the variation is gradual and does not detract from the general finished appearance of the line. Segments of broken line may vary up to 300 mm from the specified length. Segments shall be square at each end without mist or distortion. Deviations from the control line of up to 25 mm on tangents and 50 mm on curves will be accepted, provided the deviation does not increase or decrease at a rate of more than 15 mm in 10 m. Lines that do not meet these tolerances shall be removed and replaced by the Contractor at his own expense and to the satisfaction of the Engineer.

1520 REMEDIAL WORK: when it is necessary to remove paint, it shall be carried out without causing damage to the underlying pavement surface by means approved by the Engineer.

## Y31:2 REFLECTORIZED PAINT (RP) APPLICATION

2105 PAINT: thoroughly mix in the shipping container before placing in the machine tank. The paint machine tanks, connections, and spray nozzles shall be thoroughly cleaned each day with thinner before starting any spraying.

2110 MINIMUM wet film thickness for all painted areas shall be 0.4 mm and the minimum rate of application for paint marking shall be 0.40 l/m2 for smooth surfaces and 0.50 l/m2 for rough surfaces. At any point where a check indicates a deficiency in the rate of application painting shall be stopped and the equipment adjusted or replaced as necessary. Identifiable areas of paint deficiency shall be corrected to the approval of the Engineer.

2115 GLASS BEADS: immediately following the application of paint, apply a uniform layer of glass beads at the rate of 0.30 kg/m2 of paint area.

## Y31:3 PAVEMENT MARKING PAINT (MP) APPLICATION

3105 PREPARE AND APPLY pavement marking paint in number of coats and to finished thickness as recommended by paint manufacturer for particular purpose and to produce a smooth surface with neat outside edges.

# Y32 TRAFFIC SIGNS

## GENERAL

### Y32:A SUMMARY

A101 These Works consist of the furnishing and installation of traffic signs and post assemblies as shown on the Drawings, including concrete foundations and protective painting.

A110 All signs shall be lettered in both English and Arabic, unless otherwise indicated.

## MATERIAL AND PRODUCTS

### Y32:B CONCRETE

B101 concrete: shall conform with the relevant requirements of Section E11 and E12 of the Specification.

B110 concrete for POST footings: unless otherwise indicated shall be Class B.

### Y32:C REINFORCEMENT

C101 Reinforcing: shall conform with the relevant requirements of Section E21 of the Specification.

### Y32:D SIGN SUPPORTS

D101 HOT - ROLLED STEEL HOLLOW CIRCULAR SECTIONS for sign supports shall conform to ASTM A53, Type E, Grade B, unless otherwise shown on the Drawings.

D HOT - ROLLED STEEL SECTIONS AND PLATES shall conform to ASTM A36 or to Din 17100 Grade 37-2 or equal.

## Y32:F GALVANIZING

F102 All steel supports, bolts, nuts and washers shall be zinc coated in accordance with ASTM A123 or ASTM A153 as applicable.

## Y32:G PAINT

G101 PROTECTIVE PAINT: an approved oleo-resinous non-toxic protective paint system, drying to a smooth, highly opaque surface and producing a durable, flexible and water-resistant coating with excellent adhesion and colour retention. Undercoat is to be suitable to receive further coatings. Finish and colour to be selected by the Engineer from manufacturer's standard range. A guaranty to give a life to first maintenance of 10-20 years taking into consideration local climate conditions and exposure.

G205 PREPARATION MATERIALS: for cleaning, stopping, filling, sealing, priming and the like, are to be types recommended by their manufacturers and the paint system manufacturer for particular purpose and the surfaces being prepared.

G325 PRIMER FOR IRON AND STEEL: lead-based priming paint to BS 2523.

G345 PRIMER FOR GALVANIZED IRON AND STEEL: calcium plumbate priming paint to BS 3698, Type A or zinc chromate priming paint.

G365 ETCH PRIMER FOR ALUMINIUM: alcoholic solution of resin, zinc chromate and phosphoric acid.

## Y32:H SIGN MATERIALS

H101 ALUMINUM ALLOY: panels, sheets and miscellaneous hardware shall conform with ASTM B209, ASTM B211, or ASTM B221, as appropriate. All aluminum alloys shall have a minimum tensile strength of 2,500 kg/cm2 and a minimum yield strength of 2,000 kg/cm2.

H105 Sheets for plain aluminum signs shall have a minimum thickness of 3 mm unless otherwise specified.

H110 Stainless steel bolts, washers, and self-locking nuts shall conform to ASTM A276, chromium-nickel grade with a minimum yield strength of 2000 kg/cm2.

H140 washers, spacers, sleeves and the like shall be of material and types recommended by sign manufacturer for particular purpose.

## Y32:J REFLECTIVE SHEETING

J101 REFLECTIVE SHEETING: shall consist of synthetic sheet resin or other approved noncellulostic material, transparent plastic of the colours specified, and a retro-reflective system (i.e. glass spheres). These spheres shall adhere to the synthetic sheet resin and be embedded beneath a flexible transparent plastic film forming a smooth flat surface.

J105 REFLECTIVE SHEETING: shall have a precoated pressure sensitive adhesive backing, or a precoated tack-free solvent or heat activated adhesive backing. The sheeting shall adhere tightly to the prescribed surfaces when applied in accordance with the manufacturer's recommendations. The precoated adhesive shall not require additional adhesive coats on the reflective sheeting or application surface.

J110 reflective sheeting shall meet the requirements and satisfy the tests prescribed in ASTM D 4956, Type III.

## WORKMANSHIP

## Y32:1 SIGN FACES

1010 type, colour design and size of all sign faces shall be as shown on the Drawings, or in accordance with the national standards adopted and prescribed by the government authority having jurisdiction in the project location, or otherwise confirm to the standards adopted in the "European Rules Concerning Road Traffic, Signs and Signals" agreed at the 1968 Vienna Convention and subsequent supplementary provisions in the 1971 Geneva Agreements.

1120 The Contractor shall prepare and submit for approval detailed working drawings for the sign faces, in respect of all required danger, warning, regulatory and informative signs. Complete details of arrangement and spacing for lettering, and mounting hole locations, shall be shown on these drawings.

1210 Mounting hole spacing for screws, bolts or rivets shall not exceed 200 mm. Characters shall be secured to the sign using non-twist, corrosion resistant screws, bolts or rivets.

1320 The correct English and Arabic spelling of official names will be supplied by the Engineer. Sizes and style of lettering and arrows shall be as shown on the Drawings or as directed by the Engineer.

1340 The rear sign face of all signs shall be painted with 2 coats of priming paint pigmented with chromates or chromes (excluding lead chromes) followed by 2 coats of weather-resisting dull silver grey paint.

1350 Signs delivered to the Site shall be stored off the ground and under cover in an approved manner. Any sign damaged, discolored, or defaced during transportation, storage, or erection will be rejected and shall be removed and replaced by the Contractor at his own expense.

## Y32:2 FOOTINGS

2101 Post footings shall be excavated to the dimensions shown on the Drawings. Footings shall be installed and backfilled flush with the finished ground surface. Class B concrete shall be placed against the undisturbed excavated faces, except that the top 150 mm of each footing shall be formed. Forming of the entire footing will not be permitted unless approved. Concrete shall be thoroughly rodded and spaded to minimize voids. Tops of footings shall be finished with a wood float and all exposed edges shall be rounded with an edger.

2110 Backfill, where needed, shall be thoroughly compacted using mechanical tampers. Care shall be taken to prevent damage to the finished concrete. Backfill shall be brought up to finished ground level.

2120 Pipes or posts to be set in concrete bases shall be firmly supported with the correct orientation and plumbed vertical before any concrete is placed. Posts or pipes that are found to be out of plumb after installation will not be accepted and shall be removed and replaced by the Contractor at his own expense.

## Y32:3 SIGN POSTS AND SUPPORT ASSEMBLIES

3010 Signs shall normally be erected so that the edge and face of the sign are truly vertical and the face orientated as indicated on the Drawings or as directed by the Engineer to achieve the best visual effect or avoid specular reflection and glare.

3110 The Engineer will establish or confirm the longitudinal location of each sign shown on the Drawings. The Contractor shall establish the location of the sign supports and shall be responsible for the proper elevation, off-set and orientation of all signs.

3120 Post lengths: the Contractor shall be responsible for the determination of post lengths to provide the required vertical clearance. Field cutting of posts shall be performed by sawing off the bottom end.

3140 Sign Supports shall be fabricated as detailed on the Drawings. When galvanizing is specified, assemblies shall be hot-dip galvanized after fabrication. All welds shall be mechanically cleaned before galvanizing. Galvanizing materials on which the galvanizing has been damaged in transporting, handling, or erection will be rejected or may, with the approval of the Engineer, be repaired in the field by the zinc alloy stick method. Required field welds and adjacent areas on which galvanizing has been damaged shall also be galvanized by this method.

3155 Zinc alloy sticks for repair work on galvanizing shall be cast from zinc, tin and lead in combination with fluxing ingredients. The compound shall be completely liquid at a temperature not lower than 240 degrees C. The area to be regalvanized shall be thoroughly cleaned, including removal of slag on welds. The surface shall be heated with oxyacetylene torch to approximately 315 degrees C and the alloy stick rubbed over the surface to fix a deposit. While the alloy is still liquid, the deposit shall be smoothed evenly over the area using a wire brush. If a heavy deposit or build-up is required to match the original coating, more alloy shall be added immediately to the initial bond deposit and spread with a paddle or brush until the required thickness is obtained. Edges of drilled holes shall be coated with commercially available zinc-rich paint.

3160 The Contractor shall submit fabricator's certificates stating that the material supplied conforms with all of the specified requirements.

## Y32:4 FASTENING SIGNS TO POSTS

4101 Sign panels larger than 1 m2 in area shall be supported on 2 or more posts as shown on the Drawings.

4110 Signs shall be fastened to sign supports in accordance with the recommendations of the sign manufacturer and to the satisfaction of the Engineer. Fasteners shall be vandal resistant to the maximum extent practicable.

4120 All bolt heads, screw heads, and washers used to install signs on support shall be such that they do not protrude from the surface of the sign. The heads of bolts or screws shall be as nearly as practicable the same color as the background or message area at the point where the hardware is exposed.

4130 Fastener systems shall as far as practicable be designed so as not to require the drilling of the sign face.

4150 When aluminum signs are mounted with steel hardware or on steel posts, approved asphalt, nylon or neoprene insulation shall be installed at all points where dissimilar metals may come into contact.

## Y32:5 PAINTING AND SURFACE PREPARATION

5105 PROTECTIVE PAINT SYSTEM: submit for approval the names of manufacturers and products and details of the paint system proposed to be used for protective coating.

5205 ALL EXPOSED STEEL SURFACES, EXCEPT GALVANIZED SURFACES, shall be shop primed and receive field applied protective paint coating consisting of undercoats and finish coats in strict accordance with the paint manufacturer's recommendations and instructions.

5505 UNCOATED STEEL - BLAST CLEANING: steel should be without pits or depressions. Remove oil and grease by washing with white spirit or steam. Blast clean in dry atmospheric conditions using chilled iron grit to BS 7079 : Part E1 of suitable size, free from fines, moisture and oil. Continue blasting until finish complies with BS 7079 : Part A1 second quality finish. Remove abrasive residues. Prime surface as soon as possible after cleaning and in any case within 4 hours.

5511 UNCOATED STEEL - MANUAL CLEANING: where conditions preclude blast cleaning, prepare uncoated steel manually by chipping, scraping and wire-brushing surfaces to remove loose rust, loose scale, welding slag and spatter. Clean out crevices. Remove oil, grease and dirt with white spirit, avoiding spreading it over the surface. Remove residual rust with suitable chemical treatment, applying primer as soon as it has cured.

5551 PRE-PRIMED STEEL: remove dirt and grease from satisfactorily pre-primed surfaces. Remove any defective primer, rust and loose scale back to bare metal and patch prime to match existing.

5601 GALVANIZED SURFACES to receive calcium plumbate primer are to be washed with white spirit to remove dirt and grease. Galvanized surfaces to receive lead free primer are to be further washed with mild detergent solution rinsed off with clean water, pre-treated with mordant solution and retreated as necessary to achieve blackening of whole surface. If galvanizing is defective obtain instructions before proceeding.

5651 ALUMINIUM: remove any surface corrosion with fine abrasive paper lubricated with white spirit. Wash with white spirit to remove dirt and grease and apply etching primer to provide key. Small areas may be rubbed down to provide key.

# Z WATER SUPPLY, DRAINAGE AND SEWERAGE SYSTEM

## Z11 PIPES, FITTINGS AND ACCESSORIES

### GENERALLY

### Z11:A GENERAL REQUIREMENTS

A101 MANUFACTURER'S CERTIFICATE: materials are to be supplied with a certificate, in respect of each delivery, stating that products comply with and have been factory tested in accordance with specified Standards.

A201 MARKING: unless otherwise specified in the relevant Standard products are to have legibly cast, stamped or indelibly painted on, the following marks, as appropriate:

manufacturer's name, initials and identification mark

nominal diameter

class designation

initials and number of relevant Standard

length of pipe if shorter than standard length

angle of bends in degrees

date of manufacture.

A401 SPECIAL TESTS: whenever required by the Engineer, supply and transport to a testing laboratory samples of materials selected by the Engineer. Number of samples is not to be more than 0.5% of total supplied, with at least one from each class, diameter and manufacturer. Failure of any sample is to be followed by a second and if necessary a third test from the same batch. A third test failure will result in all material from that manufacturer being rejected and replaced by material from a different manufacturer, subject to approval and satisfactory tests. Provide laboratory test report in an approved form.

A601 MANUFACTURER'S RECOMMENDATIONS on handling, repairing, laying, jointing, anchoring, testing and other works for pipes, fittings, valves and accessories are to be strictly followed.


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A701 LOADING AND UNLOADING: use cranes, hoists or skidways as directed by the Engineer. Use hooks, spreader beams, ropes, band or wire slings etc. as recommended by manufacturer for each type of pipe and as approved by the Engineer.

A721 STACK pipes on level surface. Do not rest pipes on sockets or jointing fairlings. Securely chock end pipes in bottom row. Height of stack is to be to manufacturer's instructions.

A741 HANDLE material with care to avoid damage whether moved by hand, skidways or hoists.

A761 STORING: provide safe storage for material. Interior of pipes, fittings etc. are to be kept free from dirt and foreign matter. Provide shade for materials as required by manufacturer's instructions and to the Engineer's approval.

A801 CUTTING: use hacksaws, manually operated wheel cutter or pipe cutting machine as per manufacturer's instructions. If, in the opinion of the Engineer, special precautions are to be taken to eliminate airborne particles, use methods and equipment as directed by the Engineer. Prepare ends according to type of joint used and follow manufacturer's recommendations. Take care not to damage lining, if any. Repair on site, minor damage, if permitted.

A901 REPAIR DAMAGED COATING, SHEATHING OR LINING in accordance with the Specification and manufacturer's instructions. Use material compatible with that originally used. Repair is to be approved by the Engineer before incorporating materials into the work.

## MATERIALS

### Z11:H PIPES AND FITTINGS

### Z11:H2 CONCRETE PIPE FOR STORMWATER

### Z11:H21 GRAVITY PIPE

H210 REINFORCED CONCRETE PIPE AND FITTINGS: to BS 5911-1 and BS EN 1916 or to DIN V1201, and DIN EN 1916 or to ASTM C76 Class IV. Cement used in manufacture is to be ordinary portland cement to BS EN 197-1.
H214 JOINTS are to be flexible spigot and socket with rubber gasket.


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H218 FACTORY PROTECTION FOR PIPES AND FITTINGS:

Unless otherwise specified or indicated on the Drawings, internal and external lining shall not be required for storm drainage works.

Z11:H3 IRON PIPE

Z11:H32 DUCTILE IRON PRESSURE PIPE

H320 PIPE: to BS EN 545 Class K9.

H321 FITTINGS: to BS EN 545, pressure rating suitable for type of pipe and with end combinations as shown on the Drawings.

H322 JOINTS: spigot and socket ended pipes are to have rubber gasket joints.

H323 JOINTS: flanged pipes are to have screwed-on or cast-on flanges to sustain working pressure of 16 bars.

H324 FLANGES: to BS EN 1092, Part 2.

H326 FACTORY PROTECTION FOR WATER SUPPLY PIPE:

internally: cement lined to BS EN 545 with ordinary Portland cement to BS EN 197-1 to specified thicknesses.

externally: coated with metallic Zinc to BS EN 545 and followed by a coat of hot applied coal tar material to BS 4164 or a bitumen coat to BS 3416, min. thickness 150 microns.

H327 FACTORY PROTECTION FOR FITTINGS:

coated internally and externally by dipping, or other method, using hot applied coal tar based material to BS 4164 or cold applied bitumen to BS 3416, minimum thickness 250 microns.

Z11:H4 THERMOPLASTIC PIPE


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## Z11:H41 UNPLASTICIZED PVC GRAVITY PIPE

H410 PIPE: to BS EN 1401-1 or DIN EN 1401-1 and DIN 19534-3, with a minimum class of 6 bar or standard dimension ratio (SDR) of 41. Use concrete encasement if cover is less than 1.2 meter or greater than 5 meter.

H412 UPVC FITTINGS: to be injection moulded and to same standard as UPVC pipes or to BS 4660.

H414 JOINTS: Socket spigot with rubber sealing ring to BS 681-2.

## Z11:H44 UPVC PRESSURE PIPE FOR SEWERAGE

H440 PIPE: to DIN 8061 and 8062 or ISO 161, minimum Class 10 kg/cm2 with socket spigot end connections and with outside diameters to BS 2782, Part 11, Method 1121 B. Use concrete encasement if cover is less than 1.2 meter or greater than 5 meter.

H442 FITTINGS: to relevant Parts of DIN 8063.

H444 JOINTS: Socket spigot with rubber to be sealing ring type to BS 681-2..

## Z11:H45 POLYETHELENE (PE) PRESSURE PIPE FOR WATER SUPPLY (SERVICE CONNECTIONS FOR BUILDINGS)

H450 PIPE: to BS EN 12201-2:2003, Class PN6 and higher.

H452 FITTINGS: to BS EN12201-3:2003, extruded or injection moulded and suitable for class of pipe. In-line fittings including couplings, unions, bushings and nipples may be extruded or machined from extruded stock.

H454 JOINTS Joints for pipes and fittings shall be by heat fusion and in strict accordance with pipe manufactures recommendations. Joints shall have a tensile strength equal to that of the pipe. Fusion temperature, interface pressure, alignment and cooling time, shall be according to manufactures recommendations.

H458 TESTS ON PE COMPOUNDS: where PE is used for potable water, PE compounds in pipes and fittings are to contain no ingredients in an amount that has been demonstrated


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to migrate into water in quantities considered to be toxic. PE compounds are to be tested and certified suitable for potable water by the National Sanitation Foundation (NSF) Testing Laboratory - USA or the Canadian Standard Association (CSA) Testing Laboratory or other accredited testing agency. Tests are to be made in accordance with requirements no less restrictive than those in NSF 14, Sections 3 and 4. The seal and mark of the testing laboratory are to be included on pipes and fittings.

## Z11:H7 GRP PIPE DRAINAGE

H710 Pipe and fittings to AWWA C950 or BS EN 1796 and BS EN 14364. Resins, surface tissues and fibrous reinforcement as per clause 3. Pipes and fittings to be supplied with a resin rich corrosion liner- consisting of a layer of 'c' glass backed by a layer of 'E' glass all well impregnated with resin - with a nominal thickness of 1.0 mm. In addition, pipes shall be provided with a resin rich outer layer reinforced with one layer of “C” glass veil with a minimum thickness of 0.2 mm. Sand content not to exceed 50%.

Stiffness: minimum 5000 N/m2. Suitability of stiffness shall be verified by Contractor for the various trench and pipe laying conditions and as recommended by the manufacturer.

Longitudinal strength: to BS EN 1796 and BS EN 14364 or ASTM D 3262 table 7.

Strain corrosion resistance: tests are to be carried out as per ASTM D 3681 or BS EN 1796 and BS EN 14364 strain corrosion value at 50 years to equal or exceed 0.7%.

Markings: to BS EN 1796 and BS EN 14364 clause 11.

Joints: GRP double socket couplings or bell and spigot type with rubber rings to BS EN 681-2. Allowable angular deflection to BS EN 1796 and BS EN 14364.

H720 TESTING ON GRP PIPES: The following tests shall be carried out on manufactured pipes. Details of testing program to be submitted to the Engineer for review and approval prior to commencement of pipe manufacture. The manufacturer quality control scheme shall be to BS 5750 Part 8 or ISO 9004. Guidance on quality control and sampling shall be BS EN 1796 and BS EN 14364. The following tests shall be carried out and reported for approval.

- Longitudinal strength: to ASTM D 3262.
- Hydraulic test: to ASTM D 3517.
- Stiffness: to ASTM D 2412 or BS EN 1796 and BS EN 14364.
- Wall thickness: to BS EN 1796 and BS EN 14364.
- Diameter: to BS EN 1796 and BS EN 14364.
- Hardness: to ASTM D 2583.
- Loss of ignition: to ASTM D 2584.
- Hoop Tensile: to ASTM D 3517.

## Z11:X PIPE ACCESSORIES


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Z11:X1 TAPPING SADDLES

Z11:X11 CAST IRON

X110 TYPE: suitable for tapping PVC or ductile iron or PE pipes and for working pressure of 10 bars.

X112 MATERIAL: ductile cast iron or gunmetal to BS EN 1562- 10/10, BS EN 1563-420/2 or BS EN 1982 LG2- C respectively, with rubber '0' ring to BS EN 681-2 suitable for water supplies and manganese bronze high tensile non- corrosive bolts, nuts and washers.

X115 DIMENSIONS: width not less than 38 mm and diameter of disc not less than 75 mm.

X116 THREADS for tapping to BS 21.

X119 FACTORY PROTECTION: hot bitumen dipped to BS EN 10300 or cold bitumen coated to BS 3416.

WORKMANSHIP

Z11:1 GENERAL

1101 EXCAVATION AND EARTHWORK, including but not limited to pipe trenches, earthwork support, backfilling, disposal, and surface reinstatement are to be in accordance with the requirements of Division C of the Specification.

Z11:2 PIPE LAYING AND JOINTING

Z11:21 GENERALLY

2101 LOWERING: do not lower pipe into trench until pipe bed is brought to grade and approved.


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2102 LOWERING: use ropes, wire slings, band slings, spreader beams etc. as recommended by manufacturer for each type of pipe and as approved.

2111 EXAMINE MATERIAL carefully for damage. Test for soundness in accordance with manufacturer's instructions before laying.

2112 EXAMINE MATERIAL: ensure internal coating or lining and outer coating or sheathing are undamaged. If damaged, make good or dispose of as directed.

2121 PIPE CLEANLINESS: remove dirt and foreign matter before lowering.

2122 PIPE CLEANLINESS: clear construction debris from inside of pipe before making joint.

2131 PIPE PLACEMENT: lay pipe on an even formation true to grade and line, with sockets (if any) facing up the gradient.

2141 PIPE ON SOLID GROUND: cut holes in bottom of trench to allow proper jointing and for barrel of pipe to bear evenly on solid ground for its full length.

2151 PIPE ON GRANULAR BEDDING: scoop out locally at sockets/couplings to enable pipe to rest uniformly on barrel and adjust to exact line and level. After testing lay and compact further granular material in 100 mm layers to levels shown on the Drawings.

2161 PIPE ON CONCRETE BED OR SURROUND: provide rectangular blocks of concrete Class B, made in approved moulds at least 14 days before use, and approved hardwood folding wedges. Provide two concrete blocks for each pipe, set and bone into correct level on formation bottom and lay pipe properly centred and socketed. Insert two hardwood folding wedges, of width equal to width of concrete block, between body of pipe and block and drive together until pipe is brought to exact level required. Leave blocks and wedges undisturbed while pipes are being jointed and concrete bed and haunch or surround are being placed. Ensure blocks and wedges are of sufficient size and strength to prevent settlement of pipes. Leave sufficient space to enable joints to be made, tested and inspected.

2171 PIPE PLUGS: when pipe laying is not in progress, close open ends of pipes with properly fitted temporary wooden plugs or standard caps as directed.


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## Z11:22 JOINTING

2201 MANUFACTURER'S INSTRUCTIONS are to be followed regarding cleanliness of joint surfaces, lubricant used, correct location of components, provision of correct gaps between end of spigot and back of socket for flexible joints etc.

2211 DEFLECTION OF JOINT: do not deflect flexible joints beyond maximum permissible angles given by manufacturer and/or relevent Standard.

2231 PATENT DETACHABLE AND FLEXIBLE JOINTS: strictly comply with special instructions issued by manufacturer's of proprietary joints when laying and jointing.

2241 DIFFERING PIPE AND FITTING MATERIAL: joint with adaptors as recommended by pipe manufacturer.

## Z11:23 LINE AND GRADIENT

2301 IN OPEN EXCAVATION: provide and maintain sight rails and boning rods properly painted to ensure correct alignment of pipe runs. Sight rails are to be positioned either vertically above the lines of pipes or immediately adjacent thereto. At no time are there to be less than three sight rails in position on each length of pipeline under construction to any one gradient.

2311 IN HEADING: provide and maintain marks to establish line and level of pipeline. Marks are to be fixed in each working shaft and two further marks established in each length of heading.

## Z11:24 TOLERANCES

2401 GRAVITY SEWERS: tolerances are to be 6 mm in level and 25 mm in line between manholes or access points unless otherwise specified. Where pipe is to be constructed in straight lines between manholes or lampholes the length will not be accepted if a light at each manhole or lamphole cannot be seen from adjacent manholes.

## Z11:25 FLOATATION

2501 PREVENTION: whenever water is excluded from interior of pipe, place sufficient backfill above pipe to prevent floatation.


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2511 REMOVE any pipe that has floated, correct bedding and relay.

## Z11:26 PIPES BUILT INTO STRUCTURES

2601 TREATMENT OF EXTERNAL SURFACE: thoroughly clean outside surface of pipes to be built-in immediately before installation. Remove protective coating to metal pipes, where ordered. Roughen clay and concrete pipes as directed. Paint plastic pipes with appropriate solvent cement and sprinkle with dry coarse sand whilst wet. Cut away sheathing from sections to be built-in and after installation restore protection up to external face of structure with approved bituminous material.

2611 FLEXIBLE JOINTS: provide two flexible joints or flexible patented joints adjacent to structures. Place first joint not more than one pipe diameter from face of structure and second not more than the following distances away from first:

Pipelines not exceeding 450 mm: 2 pipe diameters.

## Z11:3 FIELD TESTING

## Z11:31 GENERALLY

3101 PROVIDE pumping equipment, pressure gauges, instruments and water needed for hydrostatic testing.

3106 CARRY OUT TESTS in the presence of the Engineer.

3111 FITTINGS AND JOINTS: permanently anchor fittings before testing and leave all joints exposed for checking.

3121 TEST SECTIONS: limit test sections to not more than 500 m.

3122 TEST SECTIONS: test pressure lines between valve chambers whenever possible.

3123 TEST SECTIONS: test gravity sewers in sections between manholes.

3131 TEST PLUG: secure end of main and test plug by struts.


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3136 CLOSED VALVE: do not test against a closed valve unless there is no acceptable alternative.

3141 APPLY PRESSURE by manually operated test pump or, in the case of large diameter mains, by power driven test pump, if approved.

3151 EXAMINE exposed joints and repair visible leaks.

3161 FAILURE: should a test fail, locate leak and replace or make good defective pipe or replace and make good faulty joint. Retest main.

3171 RECORDS: keep test records in an approved form. Hand original copy to the Engineer immediately after completion of test.

3181 PRESSURE LINES: carry out hydrostatic test while pipeline is partially backfilled.

3191 NON-PRESSURE LINES not exceeding 700 mm diameter are to be air tested before backfilling and hydrostatic tested after backfilling.

## Z11:32 HYDROSTATIC TESTING OF PRESSURE PIPELINES

3201 FILL PIPE slowly with water from lowest point. Do not use power-driven pump unless approved.

3211 FILL ABSORBANT PIPES with water and allow to stand for at least 24 hours to allow complete absorbtion.

3221 ENTRAPPED AIR is to be bled before pressurizing.

3231 PRESSURIZING is to continue until specified test pressure is reached in lowest part of section under test. Bleed further quantities of entrapped air while raising pressure.

3241 MAINTAIN TEST PRESSURE for specified test duration with pumping stopped.


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3251 REPRESSURIZE to original test pressure and record respective volumes of water pumped.

3261 FAILURE: pipeline will be deemed to have failed test if:

visible leaks are detected, regardless of leakage being within specified limits

volume of water lost during period when pumping was stopped exceeds allowable leakage.


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3271 TEST PRESSURE: Unless otherwise specified, the test pressure shall be equal to 1.5 times the maximum working pressure of the pipeline as shown on the Drawings or as determined by the Engineer on Site, but shall in no case exceed 75% of the factory hydrostatic test pressure.

3281 TEST PERIOD: 2 hrs.

3291 ALLOWABLE LEAKAGE: 0.1 liters/mm dia/km length/day/30 m head of applied pressure.

## Z11:33 HYDROSTATIC TESTING OF NON-PRESSURE PIPELINES

3301 PROCEDURE is to be as described in EN 1610.

3371 TEST PRESSURE: 1.2 m head of water above pipe soffit at highest point and not greater than 6 m head of water at lowest point of section under test. If maximum head is exceeded, test section in stages.

3381 TEST PERIOD: 30 minutes.

3391 ALLOWABLE LEAKAGE FOR PIPELINES: 0.5 litres/linear metre/metre diameter/30 minutes.

3395 ALLOWABLE LEAKAGE FOR PIPELINES INCLUDING STRUCTURES OR FOR STRUCTURES ALONE: As specified in EN 1610.

## Z11:37 VISUAL INSPECTION TEST

3701 TIMING: carry out test after total backfilling of length under test.

3711 LIMIT of length to be tested at one time is three full-length pipes unless otherwise approved.

3721 APPARATUS: use rubber tyred bogies which do not damage lining of pipe and an adequate supply of electric lamps.

3731 CHECK joints by means of feelers to ensure rubber rings are correctly located.


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3732 CHECK pipe barrel for visible cracks.

## Z11:38 DEFLECTION TESTS FOR GRP PIPES

3801 CONDUCT: deflection tests for GRP pipes as required by the Engineer at 3 stages. Deflection shall be measured at the spigot end at mid point and at socket end.

3811 STAGE 1: at completion of primary backfill (deflection at this stage should be below 0.5%).

3821 STAGE 2: at final backfill (Maximum allowable deflection 2.5%).

3731 STAGE 3: six months after final backfill (maximum allowable deflection 4.0%).

3732 PIPES not passing the deflection tests at stage 2 or stage 3 will be removed and replaced.

## Z11:4 WATER SUPPLY HOUSE CONNECTIONS

4101 LOCATION: agree location of tapping with the Engineer before starting construction.

4201 PROGRAMME connections to follow closely construction of main network.

4301 TAPPING: drill, thread and tap ferrule cocks to manufacturer's instructions.

4351 EXCAVATE, INSTALL, BED AND BACKFILL in same manner as main network.

4401 TEST with main network but excluding water meter.


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4501 RECORDS: maintain accurate records of location of house connections to main network. Record details of the following:

diameter

length

location

stop valves.

4551 SURVEY LOG BOOK: keep records in an approved survey log book, made available for inspection and handed to the Employer on completion. Transfer information to sketches and tables as agreed with the Engineer, provide three bound copies and hand to the Employer.

## Z11:6 CLEANING AND INSPECTION OF SEWERS

6101 CLEANING: clean pipeline of silt and debris after backfilling pipe trenches and completing manholes, hatch boxes etc. but before surfaces are permanently reinstated and make ready for inspection by the Engineer.

6201 INSPECTION: pipelines of 700 mm diameter and over are, where practicable, to be inspected from the inside and when necessary a suitable trolley is to be provided for this purpose.

6202 INSPECTION: pipelines less than 700 mm diameter and larger pipelines which cannot be inspected from the inside, are to be inspected by passing a cylinder of diameter 25 mm less than the internal diameter of the pipe and length not less than the internal diameter of the pipe through each pipeline.

## Z11:7 FLUSHING AND DISINFECTION OF WATER MAINS

7101 PROCEDURE: to AWWA C651.

7151 PROVIDE equipment, gauges, temporary connections, chlorine and water needed for flushing and disinfection.

7161 PROVIDE equipment, gauges, temporary connections and chlorine needed for flushing and disinfection. Arrange with the Employer to draw water from existing sources.


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7201 SECTIONS: flush and disinfect mains in sections as directed by the Engineer.

7211 DRAINING: use washout valves and fire hydrants to drain flushing and disinfecting water.

7221 FIRST FLUSHING: before commencing disinfection, flush main until effluent is clean and then clean as directed. 1 to 2 times volume of pipe is usually required for such flushing.

7231 TYPE OF CHLORINE: disinfect with chlorine gas or solutions of calcium hypochlorite or sodium hypochlorite and agree with the Engineer on method of application.

7241 INITIAL DOSING is to be 40-50 ppm.

7251 CONTACT PERIOD is to be 24 hours.

7261 RESIDUAL CHLORINE: measure residual chlorine by orthotolidin test. Residual chlorine is not to be less than 5 ppm or test is to be repeated as directed.

7271 FINAL FLUSHING: after disinfection, reflush network until chlorine concentration in water leaving main is less than 1 ppm.

7281 TESTS: perform bacteriological tests to AWWA C651, Section 9. Number of samples is to be one per 1 km of main feeders and one per 0.25 km of distribution lines.

7301 PROCEDURE AFTER CUTTING INTO EXISTING MAIN: generally to AWWA C651, Section 11.

## Z11:8 FIELD PROTECTION AND COATING

8101 IRON PIPES: polyethylene encasement is to be to ANSI/AWWA C105 section 4.1 or ISO 8180 or in accordance with the manufacturer's instructions. Sleeving shall be heavy duty blue color polyethylene with a minimum thickness of 225 microns.


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8901 PATENTED DETACHABLE AND FLEXIBLE JOINTS: protect metal joints with mastic compound and protective tape in accordance with the manufacturer's instructions. Minimum overlap of tape is to be 25 mm. Press out firmly all folds and irregularities.

## Z11:9 BEDDING, HAUNCHING, ENCASEMENT AND THRUST BLOCKS

### Z11:9:A GENERALLY

A101 CONCRETE WORK generally is to comply with the appropriate requirements of Sections: E11 MAKING IN SITU CONCRETE, E12 CONCRETING, E21 REINFORCEMENT FOR CONCRETE and E31 FORMWORK FOR CONCRETE.

MATERIALS

### Z11:9:R COMPRESSIBLE BOARD

R105 CONSTRUCTION JOINT MATERIAL: 20 mm thick compressible fibrous board or similar approved material.

### Z11:9:Y FILLING MATERIALS UNDER AND AROUND PIPES

Y105 INITIAL BACKFILL: selected fill, sand or other approved material conforming to the following:

| | For pipes other than uPVC and GRP | For uPVC pipes |
|---|---|---|
| Standard sieve size (mm) | Percent by weight passing | Percent by weight passing |
| 20.00 | 100 | - |
| 5.00 | 25 – 100 | 100 |
| 1.25 | 10 – 75 | 25 – 75 |
| 0.315 | 5 – 30 | 10 – 30 |
| 0.160 | 3 – 10 | 3 – 10 |
| 0.080 | 0 – 5 | 0 – 5 |

For GRP pipes: graded crushed stone 2.83 - 8 mm.


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Y305 SAND: sound, clean, uncontaminated granular material, uniformly graded from 3 mm maximum size, free from organic and deleterious matter, not containing more than 10% by weight of clay or silt individually or in combination.

Y405 CONCRETE BEDDING: in situ concrete Class C.

Y455 CONCRETE SURROUNDS, THRUST BLOCKS, ARCHES AND HAUNCHES: in situ concrete Class B.

WORKMANSHIP

Z11:9:1 GENERALLY

Z11:9:2 PLACING CONCRETE

2051 AFTER PLACING PIPE place concrete in trench and thoroughly work under pipe to provide solid and uniform bedding.

2101 AFTER PIPE JOINT IS COMPLETED place balance of concrete or haunching and work into place on both sides simultaneously.

2151 FORM VERTICAL CONSTRUCTION JOINTS in concrete beds, surrounds etc. at face of pipe joints with compressible board and finish to profile of concrete and pipe. Fill any gap between spigot and socket with approved resilient material.

Z11:9:3 PLACING MATERIAL OTHER THAN CONCRETE

3051 PLACE BEDDING MATERIAL in bottom of prepared trench and carefully hand tamp to minimum thicknesses.

3101 AFTER PIPE HAS BEEN LAID, place additional material or haunching in successive layers not exceeding 150 mm thick on both sides simultaneously. Completely fill spaces between pipe and side of trench and carefully hand tamp without disturbing pipe.

Z11:9:4 THRUST BLOCKS


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4051 GENERALLY: provide thrust blocks at bends and junctions on pressure pipelines. Additional excavation required is to be made after pipeline has been jointed. No pressure is to be applied to the thrust block until concrete has matured for at least 3 days.


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# Z13 VALVES AND ACCESSORIES

## Z13: A GENERALLY

A101 GENERAL:

MATERIALS

## Z13:U VALVES

### Z13:U11 GATE VALVES

U110 TYPE SIZE <50mm: to BS 5154 inside screw, solid wedge, rising stem and screwed bonnet.

U111 TYPE SIZE ≥50mm: to BS EN 1074-2, inside screw, solid wedge, resilient seated, bolted bonnet, non-rising stem type, suitable for a working pressure equal to 1.5 times the system operating pressure but not less than 10 bars for water supply systems.

U112 MATERIAL OF COMPONENT PARTS: from basic or alternative materials listed in BS EN 1074-1.

U114 END CONNECTIONS: either flanged to BS EN 1092 Part 2, or screw ended to BS 21 to suit joints specified for adjoining pipes.

U116 OPERATION: valves shall be operated by hand wheel.

U118 FACTORY PROTECTION: casting surfaces are to be given an initial coat of protective paint immediately after shot blasting and a second coat on assembly. Protective coating is to be hot applied coal tar or bitumen to BS 4164 or BS 3416 respectively. Minimum thickness of coating to be 250 microns.

## Z13:U5 AIR VALVES

### Z13:U51 AIR VALVES FOR WATER MAINS


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U510 GENERALLY: valves are to have cast iron body and bolted cover to BS EN 1561, Grade 14 minimum, rubber outlet seat, plastic or ebonite ball, forged bronze screws and guide for ball acting under pressure. Valves are to be dynamic type where there is no possibility of ball being drawn into orifice due to high air velocities. Valves are to be factory tested and factory coated with coal tar or bituminous coating to BS 4164 or BS 3416 respectively. Thickness of coat to be 250 microns. The pressure rating of the valve shall be 1.5 times the system operating pressure but not less than 10 bars.

U512 DOUBLE AIR VALVES (or Combination Air Valves): These are required for relieving air under pressure and in bulk. Large orifice releases or admits air during charging or emptying of mains while small orifice releases air accumulated at summits of mains under pressure. Large orifice area is to be equal to or greater than inlet of valve. Valves are to be fitted with nitrite rubber lined butterfly valve with nylon coated disc on stainless steel shaft operated by lever handle with indicator and locking thumb screw. Valves are to be flanged to BS EN 1092-2.

U514 SINGLE AIR VALVES: Type 1 (or air vacuum valve) for releasing or admitting air during filling or emptying of pipes. Type II (or air release valve) for automatically releasing, under pressure, accumulated air at summits of mains. Air valves larger than 50 mm are to be flanged to BS EN 1092 Part 2 and are to have nitrite rubber lined butterfly valve with nylon coated disc on stainless steel shaft operated by lever handle with indicator and locking thumb screw. Air valves 50 mm and smaller are to have B.S.P. thread with brass or gun metal male screwed stop valves.

## Z13:V GATES and STOPS VALVES

### Z13:V1 CAST IRON

### Z13:W FIRE HYDRANTS

### Z13:W2 UNDERGROUND TYPE

W220 TYPE: to BS 750 sluice valve type.

W222 FLANGES: to BS EN 1092, Part 2.


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W223 SPECIAL REQUIREMENTS: threads of screwed outlet or mouth piece are to suit local fire authority requirements.

W224 COVERS AND FRAMES: cast iron to BS EN 124, Heavy duty type.

W229 OPERATION BY KEYS: direction of opening is to be counter-clockwise. Operating keys are to be provided at the rate of 1 per 5 hydrants installed or fraction thereof.

## Z13:X FERRULE COCKS AND STOP VALVES FOR SERVICE CONNECTIONS

### Z13:X1 FERRULE COCKS

X110 TYPE: plug, quarter-turn closing type.

X120 MATERIAL: cast gunmetal to BS EN 1982 or cast iron body to BS EN 1561 - grade 12, and copper alloy plug.

X130 END CONNECTION: one end screwed male fitted directly to pipe saddle and other end to fit push-fit joints to polyethylene pipe as shown on the Drawings.

X140 PRESSURE CLASS: suitable for main network pressure.

X150 ACCESSORIES: surface boxes, valve caps, extension spindles and protection tube and protective cover are to be same material as specified for gate valves with dimensions and constructional details as shown on the Drawings and/or to manufacturer's standards.

### Z13:X2 UNDERGROUND STOP VALVES

X210 TYPE: to BS 5433 with crutch or square head.

X220 MATERIALS: unless otherwise specified, body, lead, gland, spindle and washer plate square head are to be gunmetal to BS EN 1982, seating washer is to be vulcanized synthetic rubber to BS 3457 Clause 6, and head sealing '0' ring is to be to BS EN 681-2, and BS 7874.


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X230 END CONNECTIONS: inlets and outlets of valves are to internally be threaded to BS EN ISO 228-1, BS EN ISO 228-2, to fit threaded specials to polyethylene pipe.

## Z13: X3 WATER METERS

## Z13: X31 INSTALLATION

X311 INSTALLATION: water flow meters shall be installed in the locations shown on the Drawings.

X312 TYPE: unless stated otherwise on the Drawings, the meter shall be of the type suitable for a normal flow stated on the drawings. It shall be accurate to within 5% over the specified flow range.


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Z13: X32 OPERATION

X321 THE METERS: shall be measure the instantaneous rate of flow as well as total flow.

X322 NO NEGATIVE RADING: shall be imposed by air passage or suction due to the emptying of the pipe system upstream from the meter.

X323 THE METER shall be made of corrosion and waer resistant materials. It shall have dial glass wipers. The meter shall sealable against unauthorized tampering.

Z13:Y JOINTING MATERIALS

Z13:Y1 GENERALLY

Y110 GASKETS: elastomeric full face 3 mm thick joint rings to ISO 4633, BS EN 681-2, or BS 7874 with dimensions to BS 3063.

Y120 RINGS: elastomeric to ISO 4633 with dimensions to manufacturer's recommendations to suit type of joint required.

Y130 BOLTS AND NUTS: ISO metric black hexagon to BS 4190, minimum tensile strength 433 MN/m2, maximum elongation 17%. After fixing, bolt projection is to be maximum 6 mm, minimum 3 mm.

Y140 WASHERS: black steel to BS 4320.

Y150 DIELECTRIC JOINTS: to have insulating gasket between flanges and Teflon sleeves and washers between bolts and nuts and flanges. Joints are to be suitable for operating pressure of system.

Z13:Y2 FLEXIBLE COUPLINGS

Y210 TYPE: gasketed sleeve type, to allow angular deflection and axial movement of two joined pipe ends and to maintain permanent, leak-tight joint.


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Y220 COMPONENTS comprise one centre sleeve, two end followers or flanges, two rubber-compounded wedge-section gaskets and sufficient draw bolts and nuts to properly compress gaskets. Tightening of bolts to draw end followers together is to compress gaskets in recess between centre sleeve and followers onto pipe ends to effect positive seal.

Y230 SIZE: couplings are to have diameter specifically supplied for and to properly fit type of joined pipe ends. Centre sleeve is to be of adequate thickness and whole coupling suitable for minimum working pressures shown on the Drawings.

Y240 CENTRE SLEEVE AND FOLLOWERS are to be true circular sections, free from irregularities, flat spots or surface defects and formed from steel mill sections with space between sleeve and follower designed to provide confinement of gasket.

Y250 BOLTS: to be special steel having minimum yield strength of 2800 kg/cm2 (40,000 psi) and ultimate strength of 4200 kg/cm2 (60,000 psi). Bolts are to be track-head design to prevent turning when nut is drawn up and threads are to be rolled with a nominal diameter larger than diameter of shank. Manufacturer is to supply information regarding recommended torque to which bolts are to be tightened.

Y260 GASKETS: to be synthetic rubber-base compound with other products to produce material which will not deteriorate from age, heat or exposure to air and which is resilient and able to resist cold flow of material so that joint will remain sealed and tight indefinately when subjected to shock, vibration, pulsation, temperature and adjustment of connected pipes.

Y270 FACTORY PROTECTION: coupling is to be factory painted internally with 5 mm coating of epoxy and externally with red primer to AWWA C203 Type B chlorinated rubber solution compatible with bitumen, coal tar and general paints.

Y280 INSTALLATION: couplings are to be assembled on site in accordance with manufacturer's instructions to ensure permanently tight joints under all conditions of expansion, contraction, shifting and settlement.

## Z13:Y3 DISMANTLING COUPLINGS

Y310 TYPE: to ensure extensible connection between sections of pipework, to be mounted next to valves to enable easy dismantling from pipework or to permit joining pipework when butterfly valve is removed for maintenance.


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Y320 COMPONENTS: dismantling piece is to be flanged type composed of two parts, one sliding into the other, and a free flange to compress a trapezoidal section seal to ensure water tightness. Coupling is to have locking devices to provide elements of complete rigidity.

Y330 CONSTRUCTION: all steel with flanges class PN 10, PN 16 or PN 25 depending upon coupling location on pipework.

Y340 SIZE: couplings are to have diameter specifically supplied for and to properly fit type of joined ends of pipes and valves. Coupling is to permit tightening of end flanges without risk of misalignment. Seal is to be locked after end joints are tightened.

## Z13:Z VALVE ACCESSORIES AND OPERATORS

### Z13:Z1 VALVE ACCESSORIES

Z110 HANDWHEELS: to BS EN1074-2, of cast iron to BS EN 1561, grade 10. Handwheels are to be marked 'CLOSE' with an arrow to indicate clockwise direction of closure. Diameters and other constructional details are to be to manufacturer's standards. Handwheels are to be supplied at a rate of one for each valve.

Z120 VALVE CAPS: to BS 5163-2, of cast iron or malleable iron to BS EN 1561, grade 12 or BS EN 1562 respectively. Set screw of valve cap is to be mild steel M12.

Z130 OPERATION KEYS: combination prising bar and lifting key type, with 1.5 m vertical bar and 0.5 m horizontal bar. Keys are to be supplied at a rate of one for every valve.

Z140 EXTENSION SPINDLES FOR GATE VALVES: steel to BS 2470 - M12, hot dip galvanized to BS EN 10255, size 18 x 18 mm for valves up to 200 mm diameter and 24 x 24 mm for valves 250 mm to 400 mm diameter. Length for each valve size is to suit excavation requirements. Spindles are to have cast iron or malleable iron cap and coupling, to BS EN 1561, grade 12 or BS EN 1562 respectively, on both sides of extension spindle (cap for operating spindle and coupling for connecting to valve). Set screws of caps and couplings are to be mild steel M12.

Z150 PROTECTION TUBES: either UPVC or cast iron. Shape, sizes and other constructional details are to be to manufacturer's standards and/or as shown on the Drawings. Tubes are to have caps circuling extension spindles.


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Z160 SURFACE BOXES: to BS 5834 : Part 2. Frames and lids are to be cast iron to BS EN 1561, grade 10, studs, bolts, nuts and hinge pins are to be mild steel M12, chains are to be mild steel or wrought iron and lid is to have the letter 'W' cast on. Boxes are to be of the medium grade type B or M:

Z170 LIFTING KEY SETS: malleable iron, supplied at the rate of 1 per cover installed or fraction thereof.

Z180 GUARDS FOR UNDERGROUND STOP VALVES: PVC, shape and size and other constructional details to manufacturer's standards and/or as shown on the Drawings.

## WORKMANSHIP

### Z13:1 GENERALLY

1051 PRIOR TO INSTALLATION, inspect for cleanliness of bores, seating surfaces etc. and for handling damage, cracks, missing parts and tightness of pressure-containing bolting.

1101 ENSURE valves, gates and hydrants are in closed position before installation.

1151 OPERATE valves and hydrants through one complete opening and closing cycle in the position in which they are to be installed to ensure proper functioning.

### Z13:2 INSTALLATION

#### Z13:21 VALVES

2101 SET AND JOINT valves to pipe in manner specified for laying and jointing pipe and/or to manufacturer's instructions.

2121 CONCRETE PADS: provide valves with Class B concrete pads as shown on the Drawings so that pipe does not support weight of valve.

2131 VALVES WITHOUT CONCRETE PADS: place on firm footing to prevent settling and excessive strain on connection to pipe.


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2141 DO NOT use valve to bring misaligned pipe into alignment during installation.

2151 INSPECT all pressure-containing bolting (bonnet, seal plate and end connections) for adequate tightness after installation but prior to field testing.

## Z13:22 HYDRANTS

2201 JOIN hydrants to pipe in manner specified for laying and jointing pipe and/or to manufacturer's instructions.
2221 SET hydrants to established grades as directed by the Engineer.

2222 SET hydrants plumb with nozzles parallel with or at right angles to the curb. Where hydrants have a pumper nozzle, set the latter facing the curb. Where hydrants have two hose nozzles 90 deg. apart, set with each nozzle facing the curb at 45 deg. angle.

## Z13:3 FIELD PROTECTION

3051 VALVES: protect valves against action of external agents by a coat of approved bituminous compound applied cold by brush after pressure tests on pipelines have been completed.

3101 HYDRANTS: apply one coat of paint, of colour specified by the Engineer, after backfilling and surface restoration is completed.

3151 GATES: protect against action of external agents with one coat of approved bituminous compound applied cold by brush after installation.

3201 BOLTS: protect buried bolts against corrosion with approved paint or by polyethylene wrapping.


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# Z25 MANHOLES, GULLIES, INLETS, CHAMBERS

## Z25:A GENERALLY

A101 EXCAVATION AND BACKFILLING generally are to comply with the appropriate requirements of Division C of the Specification.

A201 CONCRETE WORK generally is to comply with the appropriate requirements of Sections: E11 MAKING CONCRETE, E12 CONCRETING, E21 REINFORCEMENT FOR CONCRETE and E31 FORMWORK FOR CONCRETE.

## PRODUCTS

## Z25:V COATINGS

V110 COATING for internal surfaces of concrete manholes and chambers:

1000 microns minimum thickness of coal tar epoxy coating (70% epoxy, 30% coal tar), or

GRP liners to the approval of the Engineer

or other equal and approved.

V125 COATING for external surfaces of concrete manholes and chambers: 600 microns minimum thickness of coal tar epoxy coating (30% epoxy, 70% coal tar).

or other equal and approved.

## Z25:X COMPONENTS

X155 CAST IN SITU UNITS: plain and reinforced concrete for cast In-Situ units shall be Class ‘C’ and Class ‘A’, respectively. Cement is to be Portland cement to ASTM C150/ C150M Type 1, Type 2 or Type 5.

X165 PRECAST UNITS: to BS EN 1917 and BS 5911-3. Thickness shall be as indicated on the Drawings. Concrete shall be Class ‘B’. Cement shall be Portland cement to ASTM C150/ C150M Type 1 or Type 2.


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X205 BRICKS: to BS EN 771-1. Net volume of clay masonry units shall be determined according to BS EN 722-3. Water absorption of clay masonry shall be determined according to BS EN 772-7..

X305 COVERS AND FRAMES: to BS EN 124, coated to BS 3416 minimum thickness 250 microns, non-rocking, locking, solid top of circular pattern unless otherwise indicated on Drawings. Wording on cover to indicate type of network. Grades to be as follows:

- For Roadways and Open Spaces: Heavy duty test load 40 tons.

X315 ROAD GULLY GRATINGS: non-rocking to BS EN 124, coated to BS 3416. Minimum thickness 250 microns. Type to be capable of supporting a minimum test load 40 tons.

X325 STEP IRONS: to BS EN 13101:PT1.

X335 STEEL LADDERS: shall be mild steel to BS 4211 and BS EN 14396. All components shall be hot dip galvanized to BS EN ISO 1461 with 610 grams of zinc per square meter. All components shall be fabricated prior to galvanising and no modifications to the components shall be allowed after galvanising unless with the prior written approval of the Engineer.

X345 SAFETY CHAINS: shall be 12 mm diameter wrought iron short link chain, galvanized to BS EN ISO 1461 with 610 grams of zinc per square meter.

X355 GUARDRAILING: shall be tubular, mild steel, medium grade to BS EN 10255 with welded joints, galvanized to BS EN ISO 1461 with 610 grams of zinc per square meter.

## WORKMANSHIP

### Z25:1 MANHOLES AND INSPECTION CHAMBERS

1101 PRECAST UNITS: shall have been cast at least 3 weeks before sections are used. Bed lowest unit on in situ concrete base and bed and haunch in cement mortar. Liberally coat joints of units with approved bituminous material of trowelling grade prior to fixing. Ensure joints are filled solid and neatly strike off surplus compound. Do not disturb work for 7 days thereafter. Alternatively seal joints with approved preformed jointing strip in accordance with manufacturer's instructions. Bed precast concrete cover slab on top unit in cement mortar.


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1151 CHANNELS in bottom of manhole are to be smooth, semi- circular and size equal to diameter of adjacent sewers. For straight through manholes, construct channels of half pipe sections. Make changes in direction of flow with smooth curves as large as manholes permit. Changes in size and grade of channels are to be gradual and even.

1201 BENCHING: form in sulphate resisting concrete Class B to rise vertically from top of channels to a height not less than soffit of outlet pipe, then slope upwards 1 in 10 to walls. Within 3 hours, float with coat of sulphate resisting cement-sand mortar 1:2 and finish smooth with steel trowel.

1251 EXTERNAL COATING: cover faces of manholes and chambers with three coats applied by brush in accordance with manufacturer's instructions.

1301 INTERNAL COATING: cover faces of manholes and chambers with four coats applied by brush in accordance with manufacturer's instructions.

1351 STEP IRONS: cast into precast units or grout into preformed mortices. Do not use step irons as lifting eyes. Devices for lifting and handling are to be provided on exterior faces.

1401 ADJUSTMENT FOR LEVEL: build top courses of brickwork or blockwork after completion of surrounding levels. Adjust as necessary to give accurate and even final levels.

1451 COVERS AND GRATINGS: bed frame solidly in mortar with cover in position to prevent twisting. Position centrally over opening and level and square with surrounding finishes.

1501 TESTING OF MANHOLES: plug manhole inlets and outlets, fill manhole with water and allow to stand for at least 24 hours or such longer period to allow for complete absorption. Re-top with water. Allowable leakage over 24 hours is not to exceed 1% of total volume of manhole, otherwise make good and retest.

## Z25:2 VALVE CHAMBERS

2051 CONSTRUCTION: to be in situ concrete, precast concrete or blockwork as shown on the Drawings.


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2101 EXTERNAL COATING: cover faces of chambers with two to three coats applied by brush in accordance with manufacturer's instructions.

2151 COVERS: bed frame solidly in mortar with cover in position to prevent twisting. Position centrally over opening and level and square with surrounding finishes.


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# 20 GENERALLY

## 201 GENERAL INFORMATION AND REQUIREMENTS

### 201:1 SCOPE OF WORK

1101 ELECTRICAL WORK, unless otherwise specified, includes the supply, installation, testing and commissioning of the complete electrical systems, equipment and materials as well as demolition works as shown on the Drawings and/or described in the Specification together with all associated ancillary work, support work and builder's work in connection.

1201 INCOMING POWER SUPPLY AND CONNECTION will be provided by the Local Power Authority at 20 KV to the location shown on the Drawings.

1301 TELEPHONE PUBLIC EXCHANGE LINES will be brought into the premises by the Local Telephone Authority to the location shown on the Drawings and/or to be agreed with the Authority.

1401 MOTORS AND OTHER ELECTRICALLY OPERATED EQUIPMENT:

All electrical work from and including motor control centres/panels to and including motors and other electrically operated equipment, which is included in the Specification for Mechanical Work or other work, does not form part of the Electrical Work

Power supply to motors and other electrically operated equipment, which are not connected to a motor control centre/panel, is included in the Electrical Work and comprises power supply to terminal box on equipment or nearby disconnecting or starting device, and includes the disconnecting device or combination starter, as applicable and shown on the drawings, but not the equipment control panel provided by the equipment supplier.

### 201:2 GENERAL REQUIREMENTS

2101 INSTALLATIONS GENERALLY:

Carry out electrical work in accordance with the Drawings, Specification and Regulations, ensuring compliance with design and performance requirements, to provide safe and protected systems with equipment readily accessible for operation, maintenance and repair.

Installations are to be complete, ready for operation and fully integrated and coordinated with all other work

Installations are to be carried out by qualified personnel

Provide accessories necessary to complete the installations, of the types specified or recommended for the purpose by the manufacturer of the equipment or accessories.

2201 EQUIPMENT SPACES AND ROOMS: check that dimensions, structure, ventilating and cooling arrangements and other provisions in equipment spaces and rooms are suitable for installation, operation and maintenance of proposed equipment. Note any discrepancies on the shop and construction drawings.

2301 POWER SUPPLY: liaise with the Local Power Authority to confirm:

Characteristics of supply including network short circuit capacity and system earthing

Location of incoming supply shown on the Drawings

Space requirements and associated builder's work for the Authority's installations.

Make necessary arrangements at the earliest opportunity to ensure connection as and when required, and inform the Engineer in the event of any foreseen delay.

2351 KWH-METERING: liaise with the Local Power Authority and provide necessary instrumentation, enclosures and accessories required by them to effect a complete kwh-metering installation.

2401 TELEPHONE PUBLIC EXCHANGE LINES: liaise with the Local Telephone Authority to confirm location of connection of public telephone exchange lines into the premises.

2601 SYSTEMS USED BEFORE SUBSTANTIAL COMPLETION for the benefit of the Contractor are to have all consumable elements, such as lamps etc. and defective equipment replaced by new, within 7 days prior to the date of substantial completion.

## 201:3 DESIGN CONDITIONS

3101 NOMINAL CHARACTERISTICS OF POWER SUPPLY AND DISTRIBUTION are as follows:

| | | |
|---|---|---|
| Medium voltage | : | 20 kV, 3-phase, 3-wire |
| Low voltage | : | 380 V, 3-phase,<br>4-wire, solidly earthed neutral |

Frequency : 50 Hz.

3201 DISTRIBUTION SYSTEMS are to be supplied or derived from the voltage system previously described, as shown on the Drawings, or as otherwise specified.

3301 EQUIPMENT is to be designed for the system voltage and frequency previously described, unless otherwise specified. Special provisions are to be made for equipment sensitive to power supply frequency and voltage variations and for equipment operated at other voltages/frequencies or by direct current sources.

3401 KWH-METERING will be at medium voltage as shown on the Drawings.

3501 CLIMATIC CONDITIONS: equipment, including transformers, switchgear, cables, relays, lighting fixtures, motors etc., is to be designed and derated for continuous and trouble free service under the following climatic conditions:

| | | |
|---|---|---|
| altitude | : | Sea level |
| maximum ambient temperature | : | 35 deg. C (in the shade) |
| minimum ambient temperature | : | 15 deg. C |
| maximum relative humidity | : | 90% |
| atmospheric conditions | : | Hot and humid atmosphere. |

In general, equipment, apparatus, material and accessories are to be corrosion and salinity proof. UV stabilized materials shall be used for outdoor installations.

Where design and operating conditions, different from the above are required for particular equipment, they are described in the specification of the equipment concerned.

3601 REGULATIONS: carry out electrical work in accordance with the current issue of the local codes of practice, local power authority regulations and the Requirements for Electrical Installations – IET Wiring Regulations (BS 7671) as published by the Institution of Electrical Engineers, where not in contradiction with the local codes of practice and regulations, herein referred to collectively as 'the Regulations'.

3605 CONFLICT should an instance occur in this specification or on the drawings in which material or construction methods called for is less than minimum requirement of the Regulations, the Engineer shall be immediately informed in writing. Consequent to

Engineers approval, supply the materials and perform the work as through called for to minimum code standards.

3701 STANDARDS: unless otherwise specified, equipment and materials are to be manufactured and installed in compliance with the relevant recommendations of the following:

IEC : The International Electro-technical Commission

ISO : The International Standardization Organization

CCITT: The International Telephone and Telegraph Consultative Committee

CCIR : The International Radio Consultative Committee

CISPR : The International Special Committee on Radio Interference

or other equal and approved standards, herein referred to as 'the Standards'. Local standards, where enforced and relevant, are to have precedence over the Standards.

201:4 THE DRAWINGS

4101 EQUIPMENT LOCATIONS shown on the Drawings indicate the approximate locations and general layout of equipment. Exact and final locations and layouts together with dimensions, weights, mounting methods and accessories, where relevant, are to be shown on the shop and construction drawings.

4201 WIRING LAYOUTS shown on the Drawings are to be used as a guide only to defining basic positions, circuiting, loading and switching arrangements. Actual layouts and details of routing of circuits are to be shown on the shop and construction drawings.

4202 WIRING LAYOUTS shown on the Drawings for work not included in the Electrical Work, such as motor control centres/panels, cables to motors and other similar electrically operated equipment are shown for convenience and reference only.

4301 SYMBOLS: in order to provide sufficient detail and a minimum degree of clarity on the drawings, the symbols used for the various electrical devices, particularly wall mounted devices, take up more space on the drawings than the device does on the wall. Because of drafting limitations these locations must be considered as being symbolic rather than exact physical locations of the devices. The devices shall be installed with prime regard for convenience of operation and the proper usage of the wall space rather than to coincide with the scaled locations of the symbols. In locating the outlets, follow the

criteria provided on detail drawings where provided, and coordinate with furniture. Do not scale from design drawings.

## 201:5 EQUIPMENT AND MATERIALS

5101 AVAILABILITY: confirm availability of equipment and materials proposed for use in the work prior to submission for approval. If, after approval, equipment or materials cease to be available, submit alternative items of equal quality and type for approval.

5201 ACCEPTANCE BY AUTHORITY: confirm that proposed equipment and material characteristics where required are compatible with the requirements of the Local Power Authority or other authorities having jurisdiction and are acceptable to them. Inform the Engineer of any modifications necessary to comply with the Local Power Authority's requirements.

5301 MANUFACTURERS' STANDARDS: equipment is to be the latest standard product of the manufacturer. Component parts are to be the product of a single manufacturer, unless otherwise approved and provided that components made by other manufacturers are of a standard design and are interchangeable.

5351 APPROVED MANUFACTURERS: listing of approved manufacturers in the Specification does not necessarily constitute approval of their standard products as equal to those specified. Ascertain that listed manufacturers are able to supply equipment and material in conformity with the Specification.

5401 FACTORY ASSEMBLY: equipment generally is to be supplied in complete factory assembled units ready for installation on site. Dis-assembly necessary for transportation or other purposes is to be arranged to limit site work to simple re- assembly and inter-wiring of control and power cabling.

5501 STORAGE OF MATERIALS: equipment and materials are to be stored in an approved location, under cover, free from humidity, dust, debris and rodents. Equipment sensitive to heat and humidity is to be kept in climatically conditioned areas until installed and handed over.

5601 DEFECTIVE EQUIPMENT: the Employer reserves the right to operate operable defective equipment during the Defects Liability Period until it can be removed from service for repair or replacement.

5701 WARRANTY: where required by the Specification, provide a warranty, signed by the manufacturer (including his agreement to replace promptly, defective equipment or parts thereof, as instructed by the Engineer) covering materials and workmanship for the

period stated in the Specification, starting at substantial completion. The Contractor is to assign the benefits of such warranty to the Employer.

5801 SPARE PARTS: not later than the date of substantial completion, provide spare parts required by the Specification, together with suitable means of identifying, storing and securing same.

5851 TOOLS AND INSTRUMENTS: not later than the date of substantial completion, provide sets of tools and instruments required by the Specification, together with suitable means of identifying, storing and securing same.

5901 LABEL AND IDENTIFY all equipment, instruments, control and electrical devices etc. to indicate duty, service or function, to the satisfaction of the Engineer. Labels are to be laminated plastic or anodized aluminium discs with black surface and white core with incised lettering in Arabic & English. Alternative methods of labelling may be submitted for approval. Fix labels with non-corrodible screws to equipment, or to adjacent permanent surfaces or as approved by the Engineer.

5951 EQUIPMENT NAMEPLATES are to be non-corroding, robust metal, inscribed in Arabic & English, and firmly fixed to equipment at factory. Nameplates are to indicate name and address of manufacturer, model, serial number, basic characteristics and ratings of equipment and are to include elementary diagrams etc., all in accordance with the Standards.

5961 FIREPROOFING: Where cables, cable trays or conduits pass through floors and fire rated walls, pack space between wiring and sleeve full with materials and seal with approved caulking compound.

5971 NECESSARY MV/LV POWER SUPPLIES: Contractor shall be responsible to define the necessary MV/LV power supplies, taking into account the installed load of chosen equipment and final condition of installation, as well as any other considerations as to allow the proper operation and maintenance of equipment.

201:6 SUBMISSIONS

6101 GENERALLY: submit for approval, manufacturers' technical literature, shop and construction drawings and other information required by the Specification, before ordering equipment or materials and before executing any related work on site.

6151 COORDINATION STUDY: a short circuit and protection coordination study, for the electrical distribution network, is to be carried out by the contractor and submitted to the Engineer for approval

6201 TECHNICAL LITERATURE is to include detailed manufacturers' specifications and original catalogues or catalogue cuts, characteristics, model number, application and operating criteria of all equipment and materials, together with other information necessary to satisfy the Engineer that proposed equipment and systems are suitable and adequate.

6301 SHOP AND CONSTRUCTION DRAWINGS are to demonstrate to the Engineer that the design requirements are understood by indicating all equipment and material proposed to be supplied and installed and by detailing fabrication and installation methods proposed to be used. Shop and construction drawings are to clearly state the name and location of the work, the names of the Engineer and Contractor, submission date, cross-references to the Drawings and Specification and the specific reference number, location, service and function of each item.

6305 SHOP AND CONSTRUCTION DRAWINGS are to be submitted at a scale of 1:50 for general layout plans, and 1:10, or 1:20 as approved by the Engineer for sections, details, elevations, congested layouts, etc. Drawings shall include but not be limited to the following:

Details of electrical installations in conjunction with all trades concerned, showing sleeves and openings for passage through floor structure.

Composite construction drawings fully dimensioned, in metric, showing locations of cables, conduits, bus ducts, shafts, mechanical and electrical equipment rooms, ceiling spaces and all other critical locations

Plans showing equipment layouts including all details pertaining to clearances, access, sleeves, electrical connections, location and elevation of pipes, ducts, conduits, etc.

Plans, sections and elevations of electrical spaces to illustrate compliance with Standards for allocation of spaces for maintenance, movement, installation, etc.

6310 CALCULATIONS: Submit for approval the manufacturer/supplier calculations for the following systems:

Indoor and outdoor lighting distribution, with necessary supporting documents and photometric data of the approved lighting fixtures (software calculations).

Circuit Breakers selectivity and discrimination calculation study for a full selective and discriminated distribution scheme.

Voltage drop and short circuit calculations after verification of cable and breaker sizes (software calculations).

Battery bank calculations to fulfil the specification requirements provided for the specific equipment.

Rating / derating calculations for the specified equipment.

Any required calculation necessary to define component/equipment sizes for the proper operation of the electrical and ELV systems, and to confirm compliance with specified Regulations and Standards.

6501 LIST OF PROPOSED MANUFACTURERS of all equipment and materials, including all items for which choice of manufacturer is at the discretion of the Contractor, is to be submitted for approval.

6511 ASSEMBLED EQUIPMENT: any assembled equipment to be supplied for the project is to be assembled by the manufacturer or his authorized assembler. Contractor is to submit the necessary documents to substantiate the above including the assembler staff training, quality control, etc. The Engineer reserves the right to reject any local assembler if the information submitted is not sufficient. The Engineer’s decision in that respect is final and not subject to discussion.

6521 TEST CERTIFICATES AND REPORTS: submit manufacturer's type and routine test certificates and reports for equipment and devices. Complete test results are to be submitted in clearly identified and organised booklets, indicating item of equipment, make, model, type, date of tests, type of tests, descriptions and procedures. Include in the test reports the Quality Assurance Certification, the standards to which the equipment comply, and the standards to which the equipment was tested.

6531 FACTORY TESTING: for locally manufactured/assembled equipment is to comply with the relevant standards recommendations and are to be witnessed by the Engineer. If the manufacturer's test certificates/tests are not complying with the standards, then independent laboratory tests are to be carried out on equipment in accordance with the Specification and the Standards, and as required by the Engineer. The Engineer’s decision in that respect is final and not subject to discussion.

6532 FACTORY WITNESS TEST: for imported equipment, where specified in the relevant specification sections of the various electrical materials and equipments, is to be witnessed by the Engineer. Selection of equipment for witness test is to be randomly carried out by the Engineer and is to cover all ratings/types to be delivered. Witness test is to include complete routine and function testing along with any other special tests if specified, on all units to be witnessed. Test procedure and program are to be submitted for approval prior to test conduction. Factory witness test is to include for business class air tickets, five stars Hotel full accommodation, transportation and all test expenses for the number of engineers/client representatives as specified in the relevant section.

6601 SPARE PARTS SCHEDULES: submit with the Tender itemised schedules of spare parts to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.

6651 TOOLS AND INSTRUMENTS SCHEDULES: submit with the Tender itemised schedules of tools and instruments to be provided, as required by the Specification, and state against each item the manufacturer's unit price including packaging and delivery to site.

6701 LABELLING SCHEDULE: submit for approval, prior to installation, a schedule of all equipment and devices to be labelled and the suggested details, lettering, position and fixing methods of each label indicating its application.

6801 SAMPLES: submit samples of all equipment and materials for approval. Major items of equipment for which samples cannot be submitted are to be demonstrated in existing installations or by manufacturer's information, test certificates and reports.

# 202 SPECIAL REQUIREMENTS FOR ELECTRONIC EQUIPMENT

## 202:1 REQUIREMENTS

1101 CONSTRUCTION: electronic components of communication systems, security systems and special systems and electronic components forming part of the power generation and distribution system are to be solid-state integrated construction, unless otherwise approved.

1201 TEMPERATURE LIMITS: manufacturer is to indicate maximum and minimum ambient temperatures acceptable for the equipment to operate continuously and normally and beyond which electronic components may suffer permanent damage. Contractor is to coordinate the air conditioning requirements for the rooms where the equipment are located. Inform the Engineer of any special requirements or discrepancies for a decision.

1301 ALTERNATIVE ELECTRONIC EQUIPMENT may be submitted for approval, provided such equipment meets or exceeds the functional capabilities and/or performance parameters of the equipment specified. Proposals for alternative equipment will be considered only if accompanied by the following information:

List of operational characteristics and performance parameters

List of differences in operation and performance between proposed and specified equipment

List of changes required and resulting implications

Drawings indicating changes required to system wiring

Statement of advantages of proposed equipment over that specified.

1401 PROTECTION: solid state equipment under normal conditions of operation is to withstand any surges, which might be produced by sudden mains or standby power switching operations. Protective devices are to be provided to protect against surges, failure of output stages due to open circuit, short-circuit or mis-match. Comply with IEC standards and/or with IEEE standard 472 (ANSI/IEEE C37.90 "Guide for Surge Withstand Capability Tests"). System/equipment which may be adversely affected by short duration power blackouts shall be capable of riding through such a disturbance by having an internal battery back up to the memory / microprocessor, etc.

1501 INDICATOR LIGHTS other than LV pilot lamps are to be light emitting diodes (LEDs).

1551 ELECTROMAGNETIC RELAYS and control/small power transformers are to be designed to withstand the 500 V a.c. test voltage between winding and winding or winding and core.

1601 DUST COVERS, easily removable for inspection and servicing, are to be provided for all relays and sensitive elements.

1651 OUTDOOR EQUIPMENT is to be designed for maximum ambient temperature in direct sun and is to be protected/enclosed, as applicable, against dust and weather conditions.

1701 EXTERNAL INTERFERENCE: carry out field investigations and tests to determine possible interference from outside sources. Design electronic equipment to ensure trouble-free operation.

1801 SEGREGATION OF WIRING: design wiring so that low current circuits are segregated from power wiring, using different conduits and wire-ways for the purpose. Composite wiring is acceptable for the same system in accordance with the relevant codes. Cable insulation is to be same grade for all conductors in a common enclosure.

1901 POWER SUPPLY UNITS for low current systems which are fed from the LV supply are to be independently fused on the live conductor and are to have front panel mains indicator light, on/off switch and standard cartridge type fuse holder. Blown fuse indicator lamp is to be provided when fuse does not have an indicator.

# 203 TESTS ON SITE, RECORDS, TRAINING AND MAINTENANCE

## 203:1 TESTS ON SITE

1101 GENERALLY: carry out inspection and acceptance tests on site on each complete system, before final placement into service, in accordance with the Regulations and Standards, as described in the Specification and required by the Engineer.

1151 TEST SCHEDULES AND PROCEDURES are to be submitted for approval and are to include details of testing equipment to be provided.

1201 WITNESSING: inspection and acceptance tests are to be carried out in the presence of the Engineer.

1301 VISUAL INSPECTION: visually check proper installation, connections and nameplate data before testing.

1401 INSULATION RESISTANCE: test the feeders, lighting and power circuits, motors and other power equipment of low voltage installations with a megger of not less than 500 V d.c. for installations rated up to 500 V (r.m.s. value of a.c. supply) and 1000 V d.c. for installations rated above 500 V up to 1000 V, and as required by the particular Section of the Specification.

1402 INSULATION RESISTANCE: unless otherwise specified or approved, test the circuit insulation resistance related to communications and security systems with a megger of not less than 500 V operating voltage, with equipment disconnected.

1501 CONTINUITY: test all feeders and circuits for continuity.

1601 OPERATIONAL TESTS: carry out operational tests on all equipment and complete systems to verify proper performance in compliance with the Specification. Tests are to be carried out under normal operating conditions for not less than 3 days and as required by the Engineer.

1701 SPECIFIC TESTS: carry out specific tests required by the Specification and any other tests required by the Engineer to verify compliance of the installations with the Specification.

1851 VOLTAGE CHECKS: perform voltage checks throughout the building and if directed by the Engineer, adjust the transformer tap settings where a transformer is provided on the supply end, or report to power authority for adjustment necessary.

1861 CURRENT CHECKS: In cooperation with the mechanical sub-contractor, take clip-on ammeter readings on all phases of all mechanical equipment motors with motors operating under full load conditions. Test readings shall be submitted to the Engineer.

203:2 RECORDS

2101 GENERALLY: not later than the date of substantial completion, provide the Engineer with the required copies of all approved as-installed drawings, test records, manufacturers' guarantees and warranties, operating and maintenance manuals and other records required by the Specification.

2151 PRESENTATION OF RECORDS is to be in A4 size, plastic covered, loose-leaf ring binders or other approved binders with hard covers, that are indexed, divided and appropriately cover titled. Drawings larger than A4 size are to be folded in the binders so that they may be unfolded without being detached.

2201 AS-INSTALLED DRAWINGS are to contain the complete assembled information included on the construction drawings, prepared in the same manner, and up-dated to indicate the systems, labelling, referencing, mounting methods, routing etc. as installed. Submit complete drawings for approval. Drawings are to include but not limited to:

Layout plans including all conduiting and wiring installations for all systems

All changes to the work during construction including corrections that are made on floor plans and riser diagrams and detail drawings etc., as applicable.

Exact dimensioned location of all services embedded in the structure

Invert of all services entering and leaving the building and at property lines.

Dimensions and elevations of underground services in relation to building at key points of every run.

Riser diagrams for all systems

2301 TEST RECORDS are to include test certificates of type tests, routine tests, site tests, commissioning and performance tests and all other tests on equipment and installations described in the Specification and required by the Engineer. Information is to

include test procedures and results, conditions under which tests were carried out including set points, temperatures and the like, dates, location and attendance by authorized representatives etc.

2401 OPERATING AND MAINTENANCE MANUALS are to contain the following:

Technical description of each system and item of equipment installed, written to ensure that the Employer's staff fully understands the scope and facilities provided

Diagrammatic drawings of each system indicating principle components and items of equipment

Schedules (system by system) of equipment installed giving manufacturer, catalogue list numbers, model, rating, capacity and operating characteristics; each item is to have a unique code and number, cross- referenced to the diagrammatic drawings and layout drawings

Name, addresses, telephone, e-mail and fax numbers of the manufacturer of every item of equipment

Name, address, telephone and e-mail and fax numbers of equipment agents/representatives for emergency services and procedures

Manufacturer’s service manual for each major item of equipment, assembled specifically for the project, including detailed drawings, illustrations, circuit details, operating and maintenance instructions, modes of operation, control provisions, sequences and interlocks and preventative maintenance programme

Schedules of all fixed and variable equipment settings established during commissioning

Procedures for fault finding, where applicable, data or recommended maintenance procedures, maintenance intervals and maintenance tools.

All test results conducted on the relevant equipment whether at the manufacturer’s place or at site.

Manufacturers’ lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items, which may involve extended deliveries.

2402 OPERATING AND MAINTENANCE MANUALS: prepare two temporary copies with provisional record drawings and preliminary performance data and make available at time of testing and commencement of commissioning to enable the Employer's staff to familiarize themselves with the installations. Temporary copies are to be in the same

format as the final manuals with temporary insertions for items, which cannot be finalized until installations are commissioned, and performance tested.

## 203:3 TRAINING

3101 OPERATION AND MAINTENANCE TRAINING: before the date of substantial completion, explain and demonstrate to the Employer's maintenance staff the purpose, function and operation of the installations including all items and procedures listed in the operating and maintenance manuals. Include for not less than 15 days for this purpose.

3301 Factory: where specified herein and pay for the services of the manufacturer’s factory service engineer to supervise start-up of installation, check, adjust, balance and calibrate components. Provide these services as often as necessary to put installation in working order and to ensure that operating personnel are conversant with all aspects of operation, care and maintenance.

## 203:4 MAINTENANCE

4101 MAINTENANCE CONTRACTS: where required by the Specification, submit supplementary proposals for annual maintenance contracts. The proposals are to:

> Include for maintaining the installations in efficient working order including routine and emergency service checks, adjustments, lubrication and the supply and replacement of damaged parts etc.
>
> Set out the terms of the offer, the work to be carried out, the guarantees of performance and the price of the work or part thereof for the first twelve months after substantial completion.

The proposals will not be considered as part of the Tender.

# 212 TRANSFORMER SUBSTATION

## 212:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK:

Transformers substations :

Transformers substations installation comprises conventional substation including but not limited to the following:

- Indoor metal enclosed switchgear,
- Step-down Power oil-type transformers,
- Equipment supports and pedestals,
- Earthing of switchgear & transformers,
- Interconnecting power and control cabling and ancillary works.

A201 STANDARDS: equipment and component parts are to comply with the following Standards:

| | | |
|---|---|---|
| common specifications for HV switchgear and control gear standards | : | IEC 62271-1 |
| a.c. metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV | : | IEC 62271-200 |
| HV a.c. circuit breakers | : | IEC 62271-100 |
| insulation coordination | : | IEC 60071 |
| a.c. disconnectors (isolators) and earthing switches | : | IEC 62271-102 |
| Switches for rated voltages above 1 KV up to and including 52 KV | : | IEC 62271-103 |
| Additional requirements for power transformers (CTs): | | IEC 61869-2 |
| Additional requirements for capacitor voltage transformers (VTs) | : | IEC 61869-5 |
| Additional requirements for inductive voltage Transformers (VTs) | : | IEC 61869-3 |

| | | |
|---|---|---|
| relays | : | IEC 60255 |
| Surge arrestors | : | IEC 60099 |
| reading instruments | : | IEC 60051 and 60052 |
| watt-hour meters | : | IEC 62052-11, 62053-11 and 60051 |
| power transformers | : | IEC 60076 |
| insulating oil | : | IEC 60296 |
| sulphur hexafluoride | : | IEC 60376 |

A301 EQUIPMENT DATA: submit full technical data of equipment for approval including, but not limited to, the following:

manufacturers' catalogues, detailed description of construction, provisions for extension, compliance with the Standards, dimensions and weights, operating characteristics, operating curves and error curves (VT, CT) for all switchgear, control gear, protective gear, metering gear etc.

manufacturers' catalogues, detailed description of construction, dimensions, finishings etc. for power transformers and related equipment

details of miscellaneous items including pilot lights, cabling or wiring, incoming and outgoing feeder terminal fittings, supports, labels, interlocks, bracing etc.

A401 TYPE TEST CERTIFICATES are to be submitted to verify compliance with relevant Standards for each main unit or piece of equipment.

A402 TYPE TEST CERTIFICATES IN GENERAL are to include lightning impulse withstand, power frequency voltage, temperature rise, short time current withstand and enclosure protection to IEC 60529 for all main equipment.

A403 TYPE TEST CERTIFICATES FOR SWITCHGEAR are to include verification of making and breaking capacity, mechanical endurance/operation, verification of degree of protection of persons against contact with live and moving parts, and internal arc tests.

A451 ROUTINE TESTS: each complete main unit or piece of equipment is to undergo routine tests at the manufacturer's works in accordance with the relevant Standards. Submit routine test reports, prior to shipping equipment, indicating ambient test conditions and guaranteed rating of equipment under site conditions.

A461 ROUTINE TESTS AND SPECIAL TESTS FOR POWER TRANSFORMERS: all power transformers are to be subjected to factory routine testing in accordance with IEC requirements; including but not limited to winding resistance, voltage ratio, check of polarity/vector group, impedance voltage, load loss, no-load loss, no-load current, partial discharge, induced overvoltage withstand test and separate source voltage withstand test. In addition, the project transformers are to be subjected to special tests including measurement of noise power and pressure levels, temperature rise test and impulse withstand test.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

plans and elevations, with indication of equipment mounted components, dimensions and weights

arrangement of equipment and general layouts

one-line diagram of power system showing current and power ratings of all equipment, and types and locations of protective gear (relays, metering instruments, CTs, VTs) etc.

schematic and elementary diagrams of control circuits

foundation details, grouting holes, base-frames and installation details etc.

physical arrangement of incoming and outgoing feeders, terminal fittings, instrument transformers, busbars, connections etc.

dimensions and weights of control power supply and other auxiliary equipment or components.

A601 TECHNICAL LITERATURE: submit the following for approval prior to equipment manufacture:

schedule of selected equipment, relays and control gear, with complete identification of each component and its characteristics

protection coordination scheme, including pick-up settings and time-grading, together with time-current curves and range of adjustments etc. as required to coordinate with upstream and downstream protective devices of the complete system.

A701 SPARE PARTS: provide spare parts as recommended by the manufacturer, for one year maintenance as expected under local conditions, and to allow for emergency replacement due to accidental breakage or failure.

A702 SPARE PARTS FOR SWITCHGEAR are to include, but are not limited to, two sets of each type of lamp, fuse, auxiliary switch, trip-coil, control switch, selector switch, neon indicator and the like.

A703 SPARE PARTS FOR OIL FILLED TRANSFORMERS are to include, but are not limited to, one set of HV and LV bushings, drain plug, fragile parts which are subject to external damage and suitable quantity of make-up insulating oil.

A751 TOOLS AND INSTRUMENTS: provide tools and instruments required for normal routine inspection, testing, operation and maintenance, recommended by the manufacturer.

A752 TOOLS AND INSTRUMENTS FOR WITHDRAWABLE TYPE MV SWITCHGEAR are to include levering crank, manual charging handle, manual shutter operator, testing jumpers, HV test bushings, set of extension rails, set of circuit breaker lifting and handling equipment and set of appropriate wrenches and the like.

A753 TOOLS AND INSTRUMENTS FOR FIXED TYPE MV SWITCHGEAR are to include manual charging handle, testing jumpers and set of appropriate wrenches and the like.

A754 TOOLS AND INSTRUMENTS FOR OIL FILLED TRANSFORMERS are to include oil sampling kit.

A901 WARRANTY: provide a one year warranty for equipment specified in this Section.

PRODUCTS AND SYSTEMS

212:H MV SWITCHGEAR AND ACCESSORIES

212:H1 GENERAL REQUIREMENTS

H115 EARTH BUS: copper of not less than minimum size required by the Standards, designed to withstand worst earth- fault current of power system without showing any signs of thermal or mechanical damage or degradation. Earth bus is to extend full length of switchgear.

H120 POWER CABLE TERMINATIONS, whether plug-in or bolted type, are to be complete with cable terminating fittings for connection of all incoming and outgoing cables, unless otherwise specified. Cable compartments are to be designed to permit cables to enter enclosure and connect at respective terminals from below, or as shown on

the Drawings. Terminations are to include appropriate sealing ends, fittings, earthing straps and accessories for type of cables used, including stress cones or other stress relieving accessories, heat shrinkable sleeving, end boxes or end bushings and fittings of any kind necessary to support and protect specified cable.

H130 POTENTIAL INDICATORS: neon indicators are to be provided at front of each switchgear unit, one per phase, using capacitive potential divider to indicate voltage state on cable terminals.

H135 EARTHING FACILITIES are to be provided for earthing and/or short-circuiting the feeder at its terminals through built-in, safety-interlocked, quick-make earthing switch, without use of loose attachments.

H140 INTERLOCKS are to be provided on switchgear so that:

main switching device cannot be isolated and earthed when in closed position, and cannot be put into service position or closed when isolated and earthed

access to cable compartment cannot be made unless earthing switch is closed

earthing switch cannot be opened unless cable compartment is closed.

Keys and padlocks are to be provided for interlocking two or more operations as required. Mechanical interlocks are to be provided for safe and functional operation of the system.

H145 METAL CASES of instruments and control devices are to be connected by bare copper conductors, of not less than 2.5 mm2 cross-section to nearest earth bar.

H150 FERRULES: cable and wire ends are to be fitted with numbered ferrules of approved type at each termination. Colour coding is to be as required by the Regulations and the applicable Section of the Specification.

H160 TEST TERMINAL BLOCKS are to be provided inside insulating covered bases for instruments, instrument transformers, relays etc. in LV compartments.

H170 COMPONENTS are to be interchangeable when of same rating and function.

H175 FINISH: inner and outer surfaces of steel enclosures and structure are to be cleaned, phosphatized, primed with rust inhibiting primer and finished with two coats of baked enamel, colour standard grey (RAL 7033) unless otherwise approved. Finish is to be vermin and fungus proof and suitable for worst climatic conditions on site.

H180 MV SWITCHGEAR RATINGS:

| | | |
|---|---|---|
| rated voltage | : | 24 kV |
| nominal service voltage | : | 20 kV |
| rated frequency | : | 50 Hz |
| rated one minute power frequency withstand voltage (rms) to earth and between phases | : | 50 kV |
| rated impulse withstand voltage (1.2/50 micro-sec) (peak) | : | 125 kV |
| rated normal current of busbars | : | as shown on the Drawings or as specified in sub-section 212:J hereof |
| rated short-time withstand current | : | 20 kA for 1 second |
| rated peak withstand current | : | 50 kA. |

H185 AUXILIARY POWER SUPPLY RATING:

| | | |
|---|---|---|
| rated supply voltage of closing and opening devices and auxiliary circuits | : | 48 V, DC. |

## 212:H2 INDOOR WITHDRAWABLE METAL-CLAD SWITCHGEAR

H210 TYPE: categorized (LSC2B-PM), four compartments with metallic partitions, single busbar type, with horizontally isolated, withdrawable circuit breakers, floor mounted, free standing, modular design of matching units to form a continuous integral metal-clad switchgear assembly extendable at either end.

H215 DEGREE OF PROTECTION: switchgear is to have a degree of protection, against contact with live parts or contact with movable parts and against external effects, of IP 4X for enclosures and IP 2X for partitions/shutters according to IEC 62271-1 and IEC 60529, when in the connected position.

H220 CONSTRUCTION: each switchgear unit is to be divided into main switchgear compartment, busbar compartment, cable compartment and LV compartment and is to comprise withdrawable part and stationary part. Compartments are to have bolted, interconnected and earthed metal partitions. Enclosures, structure and partitions are to be galvanized steel.

H225 BUSBARS: air-insulated, high conductivity, electrolytic copper, modular, designed to withstand worst short-circuit conditions without allowing permissible temperature rise at ambient conditions to be exceeded, in accordance with the Standards. Busbar connection from one unit of switchgear to another is to be expansion/contraction compensated, plated and bolted. Busbar supports are to be flame-retardant, track-resistant, glass polyester, porcelain or equally reliable fibreglass reinforced epoxy to approved standards.

H226 BUSBARS: additional epoxy insulation is to be provided to busbars applied by the fluid-dip process. Busbar connections are to be insulated with easily installed, preformed vinyl boots, secured by nylon hardware.

H230 WITHDRAWABLE PART is to comprise circuit breaker with operating and control mechanism, isolating contacts and front shield completing the compartment enclosure, all mounted on one metal truck or carriage, provided with racking mechanism to allow for moving the withdrawable part between connected, disconnected/test (control circuits are connected) and removed positions. Isolating contacts are to be self-aligning, pressure type, silver plated copper, fully shrouded, and visible when in disconnected position.

H235 STATIONARY PART is to comprise the various compartments and required fixed components of the unit, with all operating, monitoring, setting and adjusting devices, protective relays, key interlocking and padlocking devices accessible to operator at front panel.

H240 FRONT PANEL is to include open and closed indicating lamps, on and off circuit breaker control devices, mimic diagram, padlockable earthing switch handle with indications of position and direction of rotation, and potential indicators, as a general requirement for all units.

H245 METAL SAFETY SHUTTERS are to automatically close isolator spouts in fixed compartment when withdrawable part is in disconnected position. Shutters are to be double latched for extra safety, padlockable, painted red and with the word “BUSBARS” marked in white on front of busbar shutters and painted yellow with the word “CABLE” marked in white on cable end shutters.

H250 METAL TRUCK: unless a circuit breaker is provided with a self truck, each switchgear room is to be provided with a 4-wheel type truck, with handle for racking and locking breaker into in-service or disconnected positions. Truck is to be of self-aligning design running on fixed steel rails, continuously earthed.

H260 INTERLOCKS: in addition to those specified in clause H135 hereof, interlocks are also to be provided to:

discharge the stored energy mechanism of a circuit breaker upon insertion or withdrawal from service position

prevent disconnecting auxiliary circuits while circuit breaker is in service position

prevent moving breaker into service position whilst auxiliary circuits are not connected and/or earthing switch closed

prevent complete withdrawal of circuit breaker whilst auxiliary circuits are connected

prevent closing of earthing switch when circuit breaker is in service position or between disconnected and service position.

Prevent transition from test position to either disconnect or service position while the breaker is closed.

It shall not be possible to operate the busbar-earthing device if any of the circuit breakers associated with the busbar to be earthed is in the normal service position.

Circuit breaker shall be mechanically prevented from being inserted into the service position when the busbar earth switch of the associated busbar is closed.

H265 ACCESS TO LV WIRING is to be from front of cubicle for control, protection, test terminal blocks and associated LV power connections. Multi-pin, disconnectable, lock-in type plug and socket arrangement is to be provided between withdrawable and fixed parts of switchgear.

H270 ANTI-CONDENSATION HEATERS with hygrostat, switch and pilot lamp, and of rating recommended by manufacturer are to be provided in each section of switchgear assembly.

H275 WIRING DIAGRAM, suitably protected and located inside LV compartment of each unit, is to indicate all data and components related to the particular unit and its external circuitry.

H280 VOLTAGE TRANSFORMERS with current limiting fuses are to be provided on withdrawable trucks, with identical features to circuit breaker unit, unless otherwise specified.

## 212:H3 INDOOR FIXED METAL-ENCLOSED SWITCHGEAR

H310 TYPE: For installation indoor categorized (LSC2A-PI or PM), three compartments with insulated or metallic partitions, comprising single busbar, floor mounted, free standing switchgear of modular construction, forming a continuous integral structure extendable at either end, with withdrawable mounted circuit breakers, fixed breaker-switch disconnector combination, and isolating disconnectors, as specified or shown on the Drawings.

H315 DEGREE OF PROTECTION: switchgear is to have a degree of protection, against contact with live parts and against external effects, of IP 3X for enclosures and IP 2XC for partitions according to IEC 62271-1 and IEC 60529, when in the connected position..

H320 CIRCUIT BREAKERS: to be frame mounted and bolted into position. Frame is to have wheels for handling during installation or maintenance.

H325 BUSBARS: high conductivity, electrolytic copper, modular, designed to withstand worst short-circuit conditions without allowing permissible temperature rise at ambient conditions to be exceeded, in accordance with the Standards. Busbar connection from one unit of switchgear to another is to be expansion/contraction compensated, plated and bolted. Busbar supports are to be flame-retardant, track-resistant, glass polyester, porcelain or equally reliable fibreglass reinforced epoxy to approved standards.

H326 BUSBARS: are to be insulated, either with epoxy insulation applied by the fluid-dip process or heat shrinkable insulating sleeves. Busbar connections are to be insulated with easily installed, preformed vinyl boots, secured by nylon hardware.

H330 ISOLATION: single air-break/SF6 isolator is to be provided, on busbar side of circuit breaker, interlocked with circuit breaker operation such that isolation or connection of the isolator is not possible while circuit breaker is closed. Isolators are to be pad lockable in the off and earth positions.

H340 COMPARTMENTATION is to be provided by earthed metallic or insulated partitions between switching devices, busbars, cable terminations and LV equipment.

H345 MECHANICAL INTERLOCK between the door and the switch disconnector's "Earth Position" is to be provided.

H350 CONTROL AND MONITORING of each unit is to be provided on front panel and is to include mimic diagram, operating handles of main device and earthing switches, position indicators, close and trip push buttons, potential indicators, identification and instruction plates, protective devices, metering and indicating instruments, key and padlockable devices, as specified and shown on the Drawings.

H365 ACCESS TO LV WIRING is to be from front of cubicle for control, protection, test terminal blocks and associated LV power connections. Multi-pin, disconnectable, lock-in type plug and socket arrangement is to be provided between circuit breaker and stationary part of cubicle.

H370 ANTI-CONDENSATION HEATERS with hygrostat, switch and pilot lamp, and of rating recommended by manufacturer are to be provided in each section of switchgear assembly.

H375 WIRING DIAGRAM, suitably protected and located inside LV compartment of each unit, is to indicate all data and components related to the particular unit and its external circuitry.

212:H5 MV CIRCUIT BREAKERS

H510 TYPE: SF6 circuit breaker or vacuum type.

H512 VACUUM BREAKERS: if vacuum circuit breakers are provided, surge suppresser/arrestor is to be used on each main and outgoing feeder breaker.

H515 SF6 BREAKERS: SF6 breakers, if used, are to be provided with gas filling valve and with pressure switches, one per pole, to initiate alarm in case the pressure of the SF6 gas drops below manufacturer set values. Gas filling valves are to be provided unless sealed type circuit breakers are used. Gas status indicator is to be provided on circuit breaker front.

H520 PARTICULARS: in addition to the ratings specified in clause H180 hereof, circuit breakers are to have the following ratings:

| | | |
|---|---|---|
| rated normal current | : | as shown on the Drawings or as specified in sub- |

| | | |
|---|---|---|
| | | section 212:J hereof |
| rated short-circuit breaking current at nominal service voltage and percentage d.c. component in accordance with IEC 62271-100 | : | 20 kA (metal clad LSC2B switchgear), 20 kA (metal enclosed LSC2A switchgear) |
| rated short-circuit making current (peak) | : | 50 kA (metal clad LSC2B switchgear), 50 kA (metal enclosed LSC2A switchgear) |
| rated duty operating sequence | : | 0-3min CO-3 min CO (IEC 62271-100) |
| rated transient recovery voltage (TRV) for terminal faults (peak) | : | 41 kV |
| rated (single) capacitor breaking current | : | to be stated by manufacturer (400 A minimum). |

H530 OPERATING MECHANISM: mechanically and electrically trip-free stored energy, spring loaded, manually charged by lever or hand-crank, electrically charged by suitably rated universal motor, and capable of one complete off/on/off cycle in case of loss of control power. The operating mechanism is to include anti-pumping device and incorporate manual trip facility fitted with a guard. It is to be possible to manually discharge the springs. Circuit breaker is to have electrical close solenoid and one trip coil, mechanical on and off status indicator, mechanical and electrical on/off push-buttons, mechanical indication of spring charged, non-resettable operation counter and auxiliary contacts to satisfy all functions specified or shown on the Drawings. Five N.C. and five N.O. spare contacts for future use are to be provided in addition to those required different applications. All spare auxiliary contacts are to be wired to terminal blocks inside the LV compartment marked as spare. Auxiliary relays are to be provided where insufficient auxiliary contacts are available. Insertion of manual spring charging lever or hand-crank is to automatically disconnect the motor.

H540 THE TRIPPING, closing and auxiliary functions are to be capable of operating at control voltages between 85 per cent and 110 per cent of the rated values.

H550 INTERCHANGEABILITY: circuit breakers of different current ratings are not to be interchangeable. Circuit breakers of same current rating are to be wired alike and interchangeable.

H560 MECHANICAL ENDURANCES of circuit breakers is to be class M2 according to IEC 62271-100.

## 212:H6 MV SWITCH-DISCONNECTORS (FOR INSTALLATION IN FIXED METAL-ENCLOSED SWITCHGEAR)

H605 SWITCH-DISCONNECTOR: general purpose, 3-pole, load- break, short-circuit make, SF6 type, equipped with gas pressure indicator with alarm contacts, category B to IEC 62271-103, providing positive break indication, as defined in IEC 62271-102, with contact position indicating device and reliable method of preventing any earth leakage currents passing from terminals of one side to terminals of other side of the switch-disconnector when in the open position.

H610 SWITCH-DISCONNECTOR OPERATION is to be electrically and manually through handles at front of unit. Switching mechanism is to be manual, motor operated, spring charged, quick make and quick-break, with speed of switching independent of operator. On/off control push buttons shall be provided for controlling the switch. Switch-disconnector is to have on and off positions, lockable in either position. Reliable mechanical indicator is to be provided for indicating the two positions.

H620 SWITCH-DISCONNECTOR EARTHING SWITCH of the quick-make type, front operated (operation being independent of operator), is to close onto cable terminals and be interlocked such that it will close only after load-break switch- disconnector and associated breaker are open. Earth blades are to be visible through an inspection window. Access to cable compartment is to be prevented unless earthing switch is closed.

H630 SWITCH-DISCONNECTOR RATINGS:

| | | |
|---|---|---|
| rated normal current | : | 630 A |
| rated short-circuit making capacity | : | 50 kA. |
| rated short time current | : | 20 kA for 1 sec. |

## 212:H7 PROTECTIVE RELAYS, DEVICES AND AUXILIARIES

H710 PROTECTIVE RELAYS: digital, programmable, solid state, static, sealed type, having high immunity to electric field, with modular design, suitable for operation at 55 deg. C ambient temperature, mounted in dust-tight steel enclosures with cover, with self supervision system test buttons for testing without removing from case, and built in self regulated power supply unit and installed where shown on the Drawings. Adjustments and settings are to be accessible and visible from front of relay. Performance is to be in compliance with IEC 60255-151, -8, -1 and IEC 60255-26 (Sections 1-4) and as applicable elsewhere in this specifications.

H712 PROTECTIVE RELAY: is to be supplied with DC power from the switchgear power supply, and to be provided with a pilot LED which is to be lit under healthy operating conditions. Relay is to be provided with a self supervision system which upon power supply interruption or a fault condition is to switch off the LED and to initiate an alarm. The rated current and voltage for current & voltage sensing relays are to match that of the corresponding current and voltage transformers of the switchgear respectively. The continuous rating of the output contacts is not to be less than 5A.

H715 INTERFERENCE AND TEST VOLTAGES of the solid state relays are to be as follows:

| | | |
|---|---|---|
| Insulation test voltage, terminal groups between themselves and the relay frame work as per IEC 60255-27 | : | 2 kV, 50 Hz, 1 min. |
| Impulse test voltage, terminal groups between themselves and the relay frame work as per IEC 60255-151 | : | 5 kV, 1.2/50 micro sec |
| High frequency test voltage, terminal groups Between themselves and the relay frame work as per IEC 60255-1 | : | 2.5 kV, 1MHZ |

H720 OVER CURRENT RELAY: 3 phase, non-directional, solid state type with two setting stages as follows:

Low setting stage for overload protection with current setting range of 50 % to 250 % of rated current in steps of 5% and adjustable definite time and inverse time operation modes as per IEC 60255-151.

High setting stage (instantaneous) for short circuit protection with current setting range up to 4000% of rated current.

H725 EARTH FAULT RELAY, non-directional, solid state type with two setting stages as follows:

Low setting stage of 10 % to 80 % of rated current and adjustable definite time and inverse time operation modes as per IEC 60255-151.

High setting stage (instantaneous) with current setting range up to 1000% of rated current.

For transformer protection the time and instantaneous units shall not operate on inrush or due to harmonic currents during transformer energization or on system faults. Separate additional harmonic restraint relays may have to be provided, if required based on the transformer manufacturer's data.

H730 RESTRICTED EARTH FAULT RELAY, on secondaries of distribution transformers and generators having a solidly grounded neutral and rated over 500 kVA if specified or indicated on the drawings, is to be high impedance, instantaneous differential type, current calibrated from 1% - 20% of phase current.

H740 UNDER-VOLTAGE AND OVER VOLTAGE RELAYS: three phase or three single phase, solid state definite time type with the following setting ranges:

Under voltage relay: 60 % to 90 % of rated voltage and 0.2 to 6 sec time delay.

Over voltage relay: 80 % to 130 % of rated voltage and 0.2 to 6 sec time delay.

H745 UNDER-VOLTAGE AND PHASE-SEQUENCE RELAYS: under-voltage relay is to be time-delay type, with selectable time/voltage characteristics 0.1 - 1.0 seconds for settings between 60% and 90% of normal voltage, sensed at VT secondaries. Combined under-voltage and phase-sequence relays are to be provided where specified or shown on the Drawings. Phase- sequence relay is to prevent operation (closing) of respective circuit breaker in case of non-conformance of phase rotation.

H750 EACH RELAY is to be provided with an interface data link (IEC 61850 or equivalent) and adequate number of contacts for tripping annunciation, and interface with MV supervision network functions.

H755 AUXILIARY RELAY: to be suitably rated and with sufficient number of N.O. and N.C. contacts for operation in conjunction with protective relays or control/interlocking requirements. Relay is to have two N.O. and two N.C. spare contacts.

H760 SURGE ARRESTERS: gapless, metal oxide, heavy duty type, with the following characteristics:

| | | |
|---|---|---|
| Arrestor rated voltage | : | 17.5 kV |
| Maximum continuous operating voltage (Uc) | : | 15 kV |
| Nominal discharge current (8/20 micro-sec peak) | : | 10 kA. |
| Energy input capacity | : | 3.5 kJ/kV |

Surge arresters are to be vertical, free standing, explosion-proof type. Submit complete data and characteristics in accordance with IEC 60099 testing requirements and procedures.

H770 CONTROL POWER SUPPLY is to be complete system, including main LV switch, battery charger, batteries, racks and connectors, factory assembled and completely prewired to minimize field installation.

H775 AUXILIARY LV POWER is to be obtained from a self contained control power transformer unit supplied with the switchgear, when specified or shown on the Drawings.

H780 BATTERY: Nickel cadmium type, of capacity sufficient to supply all MV switchgear auxiliary loads and other substation auxiliary control loads, relays, coils, lamps, alarms etc. for 8 hours, to close all circuit breakers in rapid succession and trip all circuit breakers simultaneously with the charger off. Battery is to be heavy duty type with transparent containers and maximum and minimum electrolyte level indicators and alarm initiating relay in case of D.C. output failure. Battery calculation is to be submitted according to IEEE 1115 based on simultaneous trip of all circuit breakers in T1 (1 minute) period, continuous load in T2 (758 minutes) period, and successive close of all circuit breakers in T3 (1 minute) period. Batteries are to be sized for nominal system voltage +10% -15%. Calculation is to consider the following factors: 1.15 design margin and 1.25 aging factor.

H782 BATTERY RACKS: to be generously dimensioned termite resistant hardware with electrolyte resistant paint finish, or square sectioned steel tubes treated with electrolyte resistant extruded coating. Fittings and connectors are to be approved and certified electrolyte resisting and corrosion proof materials.

H785 BATTERY CHARGER: automatic voltage controlled, solid state type, suitable for float and boost charging, returning batteries to 90% full charge within 4 hours after full discharge, plus full duty cycle required of batteries. Charger is to operate from 220 V supply, 50 Hz, single- phase, giving specified DC output, and having minimum range of adjustment of 100% - 125% float voltage and 110% - 135% boost voltage. Ripple is not to exceed 3% of nominal output voltage. Output voltage regulation tolerance is to be +/- 1%. Output transient response is to be +/- 5% maximum of the DC voltage setting for 100% step load changes with recovery time of 500 m sec to steady state. Charger is to be rated 125% of its nominal full load and is to have its own automatic control against overcharging and overload protection. Charger is to have AC voltmeter, DC voltmeter, DC ammeter, main incoming circuit breaker, pilot lights on AC input and DC output and earth fault detector with alarm indication.

H790 BATTERY CHARGER TYPE: is to be single charger type.

## 212:H8 METERING INSTRUMENTS - INSTRUMENT TRANSFORMERS

H801 PROVIDE METERING INSTRUMENTS and instrument transformers as specified and/or shown on the darwings.

H810 INSTRUMENTS GENERALLY: to be housed in enamelled, square steel cases for switchboard flush installation, 96x96 mm, with 5 mm frontal, protected and sealed white background dials with black pointers (in general) and anti- parallax shadow-proof glass covers. Accuracy of instruments is to be class 1.5 unless otherwise specified. Moving parts are to be damped, revolving on hardstone bases, with zero adjustment screw.

H820 AC VOLTMETERS: moving iron type, operating from VT secondaries, and with the following characteristics:

| | | |
|---|---|---|
| measuring range | : | 30 kV<br>90 deg. decimal scale |
| overload factor | : | 1.2 times rated voltage continuous and twice rated voltage for 1 minute. |

H825 DC VOLTMETERS: moving coil type, with the following characteristics:

| | | |
|---|---|---|
| measuring range | : | 60 V |
| overload factor | : | 1.2 times rated voltage continuous and twice rated voltage for 1 minute. |

H830 VOLTMETER SELECTOR SWITCH: 7-position, rotary type, with cam-operated contacts, permitting line-to-line and line- to-neutral voltage readings, and an off position.

H840 AC AMMETERS: moving iron type, operating from CT secondary, and with the following characteristics:

| | | |
|---|---|---|
| measuring range | : | 1.25 times CT primary amps<br>90 deg. decimal scale |
| overload capacity | : | 1.2 times measuring range continuous, twice measuring range for 2 minutes, and ten times measuring range for 1 second. |

H845 D.C. AMMETERS: moving coil type, with the following characteristics:

| | | |
|---|---|---|
| measuring range | : | 2 x normal d.c Range A |
| overload capacity | : | ten times measuring range for 5 seconds. |

H850 POWER FACTOR METERS: totally enclosed, 3-phase, electro- dynamic type, with cross-coil meter movement and accuracy of 1% from at least 20% - 100% rated current at rated voltage.

Measuring range : 0.1 conductive-unity-0.1 capacitive

H860 WATT-METERS: totally enclosed, 3-phase, electro-dynamic type, with overload factor of 1.2 times continuous.

Measuring range : 1.25 x required range

H865 WATT-HOUR METERS: 3-phase, to IEC 62052-11, 62053-11 and 60051, unless otherwise required by the Local Power Authority.

H870 FREQUENCY METERS: vibration (reed) type, rated frequency 50 Hz, class 1, rated frequency range 45-55 Hz, and unaffected by voltage variations of +/-20%.

H880 CURRENT TRANSFORMERS (CTs): indoor dry type (cast- resin), with the following characteristics:

metering (general) : Class 1, 5 A secondary

protection : 5 P15, 5 A secondary

Continuous current Factor : 1.2

Troid current transformer enclosing the three phase conductors is to be provided for zero sequence earth fault protection where required on drawings.

Rated primary current, core size and accuracy limit factor are to be determined in accordance with nominal current of plant protected, short-circuit level and burden. CT is to perform under specified conditions without exceeding accuracy limit. Submit error curves for approval. Thermal short-circuit rating is to be the same as specified for the MV switchgear with dynamic short-circuit rating of 2.5 times thermal rating.

H890 VOLTAGE TRANSFORMERS (VTs): magnetic, single-phase, indoor, dry type (cast-resin encapsulated), with the following characteristics:

rated voltage:

primary : 20/(sqrt 3) kV

secondary : 100/(sqrt 3) V

accuracy class : 0.5 for metering and 3P for protection

rated voltage factor : 1.2 continuous, 1.9 for 30 seconds.

Check associated burden and ensure VT can perform satisfactorily under specified conditions. Submit error curves for approval.

212:J MV SWITCHGEAR ASSEMBLIES

Interlocks required by applicable IEC Standards are to be provided.

212:J3 MVSWG-7 (SS6)

Below details are to be considered as complementary to the data provided on drawings.

J310 MV SWITCHGEAR ASSEMBLY: cubicle type fixed switchgear with:

2 incoming feeder, switch-disconnector ring unit(s)

2 outgoing feeder, fixed circuit breaker unit(s).

J311 INCOMING FEEDER UNIT NO. is to comprise at least the following and as shown on drawings:

set of copper busbars, 630 A

main switch-disconnector, 630 A

key locks

three CTs for ammeters, ratio 630 / 5 A

three ammeters as specified

earthing switch

set of cable terminations

Refer to MV SLD for the details of required protections.

J313 OUTGOING FEEDER UNIT TO TRANSFORMER is to at least comprise the following and as shown on drawings:

set of copper busbars, 630 A

fixed circuit breaker, 630 A

earthing switch

three CTs for ammeters, ratio 630 / 5 A

three ammeters as specified

three CTs for protection, ratio 630 / 5 A

over current and earth fault IDMT relays, very inverse or extremely inverse characteristics and instantaneous protection - Refer to MV SLD for the details of required protections.

one watthour demand meter, 15 min. demand interval (with voltage from imu)

set of cable terminations.

## 212 :K MV SUPERVISION NETWORK

The following section is description of the technical charasteristics of the MV Supervision Network that will be implemented for the MV distribution system and networks.

K100 MV supervision network to be the State of Art, complete with all components and peripheral equipment to ensure compelete distribution network supervision for the whole installations.

K101 System to be complete with redundant servers, redundant communication ring, communication interfaces, web access, independent UPS, console, workstations (at least 2 Nos. each 32-inch), printers, desk and necessaty furniture, software, etc... for the intended function.

K105 Supervision shall mean control and monitoring, manual via Operator or automatic through the system itself. The System shall offer real-time monitoring & control features over the electrical distribution system.

K110 System should be user friendly and capable of manual and automatic reconfiguration of the loops based on the available power supply sources, conditions of the

distribution network, etc. System shall be capable of optimizing load distribution between sources and within each loop.

K115 Communication with generators' control panels to be provided in order to ensure correct monitoring andstart up/synchronization control.

K120 Architecture of the System shall be based on the following functionalities:

- IEC61850 Standard,
- Modbus TCPIP Communication,
- DNP3 Standard,
- IED communication either direct through Ethernet or a gateway.

K125 System shall be an open solution that can be easily expanded into a larger system. It shall be based on a distributed and modular architecture. The System is designed to change as the site evolves over time, including:

- The System shall be easily scalable,
- The System shall support on-line updates through the use of redundant configurations of IO servers (no system downtime),
- The System shall have upgrades that will be managed to be compatible over time.

K130 Depending on the number of devices, the I/O server load shall be distributed on several I/O servers, in order to manage the time performance of the system, with the clustering functionality. This provides support for configurations with a large number of IEDs connected.

K135 The following communication characteristics shall be supported within the System software:

- IEC61850 standard,
- Modbus TCP communication including time stamped data and waveform formats,
- DNP3,
- SNMP protocol,
- NTP protocol,
- OPC DA client.

K140 The System shall support several schemes for redundancy to ensure reliability of the system operation at all times. Within the System the schemes for redundancy shall have the following characteristics. Failure of a system component shall not disable the system or put part of out of function. Contractor to demonstrate the above during submittal approval.

- Redundant I/O Servers: Primary / Standby,
- Redundant Network: Self healing ring and redundant distribution,
- Redundant Serial Line: Redundant gateway and device dual port attachment,
- Redundant PLCs.

K145 The System shall achieve millisecond time-stamping of alarms and events, with a comprehensive time synchronization solution. Time synchronization between IEDs, PLCs, and the I/O servers shall be maintained.

K150 The System shall support both View only and Control Clients for the Operators, Managers and Engineers, depending on the site topology:

- The Control Client provides the user with monitoring & control capabilities,
- The View Only Client provides the user with only view / monitoring capabilities,
- The Web Client (available in either View only or Control versions) which provides those capabilities over the web.

All user specific privileges shall be configurable.

K155 The System shall natively support the following data:

- Real-time data from any device on Modbus TCP/IP,
- Waveform captures from devices,
- Time-stamped data from devices.

K160 The System shall be dedicated to real-time monitoring of all electrical distribution devices at site. The System shall communicate with all devices at site and monitor all data available within the devices, including real-time data and advanced information such as time-stamped data or waveforms. The single-line diagrams shall be dynamically animated with:

- Status of the equipment,
- Analogue measurements,
- Busbar dynamic colouring: the busbar changes of colour dynamically depending on the status of the equipment and the voltage level on the busbar. The colouring of the busbars and equipment shall depend on the status and the voltage level.

The definition of colours for each voltage level shall be configurable.

K165 Each electrical distribution equipment, such as a circuit breaker, shall be defined as an object and monitored in real-time. The object shall be animated in real-time, i.e. its status, and the analogue information.

- CB Status: open, close, intermediate, error,
- CB Information: communication status, racked in/out, local/remote, tripping, health status,

- Alarm status.

By clicking on the object, the user shall have access to a first pop-up. From this pop-up, the user shall have access to the trending or to a secondary pop-up, which displays the complete information available for this equipment.

K170 Navigation through the single-line pages can be done through the secondary menu bars or directly on the single-line page by clicking on active links on the page.

K175 Alarm & Events Tab: Several types of alarms and events pages will be available, through the secondary menu bar:

- Event view,
- Active alarms view (active and unacknowledged),
- Unacknowledged alarm view,
- Disabled alarm view.

System should be able to customize additional views for alarms. On each of these views, list navigation shall be performed by page up/down buttons.Each view allows for filtering of the list. From an alarm, the user shall:

- Access the associated single line diagram,
- The ability to acknowledge/disable the alarm,
- Access any associated waveform,
- Access to detailed view of the data associated with the equipment.

K180 Analysis Tab shall display real time trends and historical trends. It shall be possible to select and monitor historical data tags. The trending function shall have the following characteristics:

Instant Trend (Real-Time Analysis):

- Capacity to save and print an instant trend,
- Ability for trend data to be saved/export for re-use in an Excel or Word document,
- Data sampling period is configurable at runtime.

Trending (Historical Analysis):

- Capacity to view historical trends,
- Capacity to view Alarms,
- Capacity to save trends.

K185 System Tab: The System screen shall allow the user the capability to monitor the communication network.

K190 User Access shall be controlled by configuring privileges. The System shall provide a matrix that can be configured to the needs of the project. Privileges can be defined to describe the access rights of an Operator/Engineer/Administrator at each site.
By default, the System shall be defined with the following privilege levels:

- CB, Switch control,
- Alarms acknowledgement,
- PC-based alarms configuration,
- User Administration,
- Shutdown Runtime.

From these privileges, the System shall define standard operating roles that are combinations of these privileges.

K195 Control features: The System shall provide secured user access to control operations for equipment such as:

- Close circuit breakers,
- Open circuit breakers,
- Close switches,
- Open switches.

K200 Controls shall be secured through a sequence of commands which operates with the following functionalities:

  - Verify operator has the user rights to perform a control,
  - Pop-up window requires operator confirmation to perform device control,
  - Event logging of operator actions,
  - Failed control execution results in an event.

K205 Alarm & Event Functionalities: The System shall manage alarms and events for the electrical distribution site. An event is a time-marked occurrence. An alarm is an occurrence, typically an abnormal state that the user is required to acknowledge.

- Field alarms (On-board): alarms coming from the IEDs with millisecond precision time stamp.
- System-based alarms (PC Based): alarms generated by the System software based on a pre-defined logic, such as:

  - Analogue alarms (use of dead-bands),
  - Digital alarms (status checked) ,
  - System state,
  - Communications state.

K210 Alarm/Events Log: The System shall consist of several alarm / event views with the following functionalities:

- Event View: One consolidated view for all recorded events and alarms.
- Alarm Views:
    - Alarm Banner: Indicates last five active and unacknowledged alarms: Viewable on all screens,
    - Active Alarm View: Indicates all active and unacknowledged alarms,
    - Unacknowledged alarms view,
    - Disabled alarms view: Ability to disable alarms on a per-alarm basis.
- Alarm / Event viewing features:
    - Time-stamped events / alarms,
    - Chronological sorting,
    - Advanced filtering capabilities,
    - Print support: Complete view and/or sorted and filtered view,
    - Run-time layout control (Administrator only): Add / remove columns and/or Resize columns,
    - Configurable colour coding based on severity of alarms.
- Pop-up menu access from each alarm to:
    - Link to a single line diagram associated with the equipment,
    - A detail view associated with the equipment,
    - Ability to change Alarm Setpoints (limits) during run-time,
    - Ability to acknowledge an alarm,
    - Ability to disable an alarm,
    - Ability to view an associated waveform for supported devices.
- Secure Alarm / Event Access:
    - Events cannot be deleted or changed,
    - Acknowledging Alarms: User privilege is verified / User actions logged,
    - Disabling Alarms: User privilege is verified / User actions logged,
    - Changing Alarm Setpoints (during run-time): User privilege is verified/ User actions logged.

The Administrator shall have the ability at runtime to change the order of columns. The standard columns available shall be:

| Item | Alarm List | Event Log |
|---|---|---|
| Date | Yes | Yes |
| Time | Yes | Yes |
| State | Acknowledged/ Unacknowledged/Disabled | Acknowledged/Unacknowledged/ Disabled /Appearance/Disappearance |
| Equipment | Yes | Yes |
| Description | Yes | Yes |
| Location | Yes | Yes |
| User | No | Yes |

K215 Level of Alarms: By default the System shall provide 3 criticality levels for alarms:

- **High**: trip / power supply disruption,
- **Medium**: alarm that prevents operation of the System, such as communication failure, or status discrepancies,
- **Low**: alarms that do not interrupt operation of the System, but require attention, such as transformer overload.

These criticality levels shall be specified for alarms at configuration time.

K220 Alarm Filtering Capabilities: The System shall have the capability to perform alarm filtering. The following characteristics shall be present in the alarm filtering function:

- Date/Time: all alarms/events between a start and end date,
- State : Appear / Disappear / Acknowledged (alarms) / Disabled (alarms),
- Location: this shall follow the IEC61850 tag naming convention,
- Criticality levels: 3 levels minimum,
- Equipment name,
- Areas: grouping of alarms,
- Description,
- Custom Field,
- Alarm Attributes:
    - Type: Power quality, Protection, System,
    - Group: Currents, Voltage, Power, Power Factor, Energies, Demands, etc.
    - Categorization: Sag/Swell, Over/Under, Transients, Loss, Interuptions, etc.

K225 Alert Management: Alerts shall be triggered by an alarm. The System shall provide the ability, upon an alarm criticality level, to:

- Annunciation : operate a horn
- Print the alarm message on an alarm printer
- Run other programs (and scripts) driven by events, like e.g. report generators, 3rd party messaging systems
- Alerts could be cancelled in an easy way (<ESC> type)
- Each alarm noise is superseded by an alarm of higher priority, e.g. if a priority 2 alarms currently being played and a priority 1 alarm becomes active the alarm noise will change to the noise for a priority 1 alarm. Silencing the alarm will then silence all alarms i.e. the priority 2 noise will not then be played.

K230 Navigation with Alarms: When an alarm goes active, the alarm shall appear in:

- the event log,
- the active alarms log,

- the unacknowledged alarms log,
- the alarm banner.

From any of those logs (except the alarm banner), it shall be possible to access the object view on the corresponding single-line diagram view page. The alarm shall be also accessible from the corresponding object's detail pop-up.

K235 System-based Alarms: The System shall provide a wide range of System-based alarms. The standard set includes:

- Communication loss of devices,
- Incomer/Feeder Power outside dead-band: Defined dead-bands / Several incomer possible,
- Frequency level: Defined dead-bands,
- Voltage level: Defined dead-bands / Several voltage levels possible,
- CB normal status change: Define typical status change,
- Local/Remote status of device: Digital status.

These alarms shall be configured at configuration time. The analogue Systyem-based alarms shall be modified at runtime by the Operator, with a specific set-up page with limited user access ability: dead-bands and set-points can be modified over time by the engineer at site to tune the alarm trigger point.

K240 System shall provide the user interface for 2 types of trending:

- Instant Trending (real-time): Operator shall have the ability to select any configured real-time tag in the system and monitor it in real time. i.e. to monitor a specific event. The instant trend shall have the following functionalities:
    - Instant trending shall be available for any real-time tag, monitored by the system,
    - Time sampling shall be configured during runtime and is defined by default to 1s,
    - Instant trends can be saved as *.csv files and exported to other applications, such as Excel.

- Historical Trending: Operator shall have the ability to select any pre-defined trend tag in the system and do analysis on that data. The historical trending shall have the following functionalities:
    - The data to be trended is configured at configuration time along with the sampling rate,
    - The System shall provide as standard features the following trends: Active power, Voltage,Frequency, Current.

    Historical trends shall be saved on hard disk / period is 2 years by default (memory is a FIFO type). From the equipment pop-up the user can bring up the predefined set of related historical trends, such as: Active power, Voltage, Frequency, Current.

K245 Waveform Capture Analysis: The System shall download waveforms from supported devices and provide an interface for analysing their data. Waveforms shall be linked to the associated alarm and viewable from the active alarm page. All waveforms captured shall be stored on the hard drive. The System shall provide an active X tool that can be used to view and analyze these waveforms. The following different viewing options shall be included:

- Individual current or voltage phases shall be viewed,
- The ability to view an overlay of the phase currents shall be supported,
- The ability to view an overlay of the phase voltages shall be supported,
- The ability to view an overlay of the current and voltage phases shall be supported,
- The system shall have the capability to view a spectral plot that is used to view harmonics,
- The system shall have the capability to view /calculate the True RMS,
- Shall be able to import and display waveforms that have been exported to disk,
- Several methods of navigating the waveform shall be supported,
- The ability to zoom in and zoom out by highlighting a specific area of interest (rubber-banding).

K250 Configuration Tools: System shall supply libraries of predefined device/equipment graphics, and also supply configuration tools to allow the user to create additional or customize existing libraries. The System shall be shipped with configuration tools that predefine tags for a selected set of devices. The predefined tags are called device types, and these device types are comprised of real-time, trend and alarm tags. The configuration tools shall provide an interface that will allow the user to create additional device support for any other devices that may exist in their system. The user may also modify existing device types and their associated profiles. The configuration tools shall provide two mechanisms for setting up the System databases. One interface shall be user friendly making it easy for the user to add devices to their system. Another interface shall also be provided for automated bulk data base generation, essential for large systems.

K255 Configuration Tools shall provide the ability to create new device types in addition to the device types that are shipped as standard. The tool shall provide a complete set of pre-defined data attributes associated with each tag. The following attributes must exist in the tool.

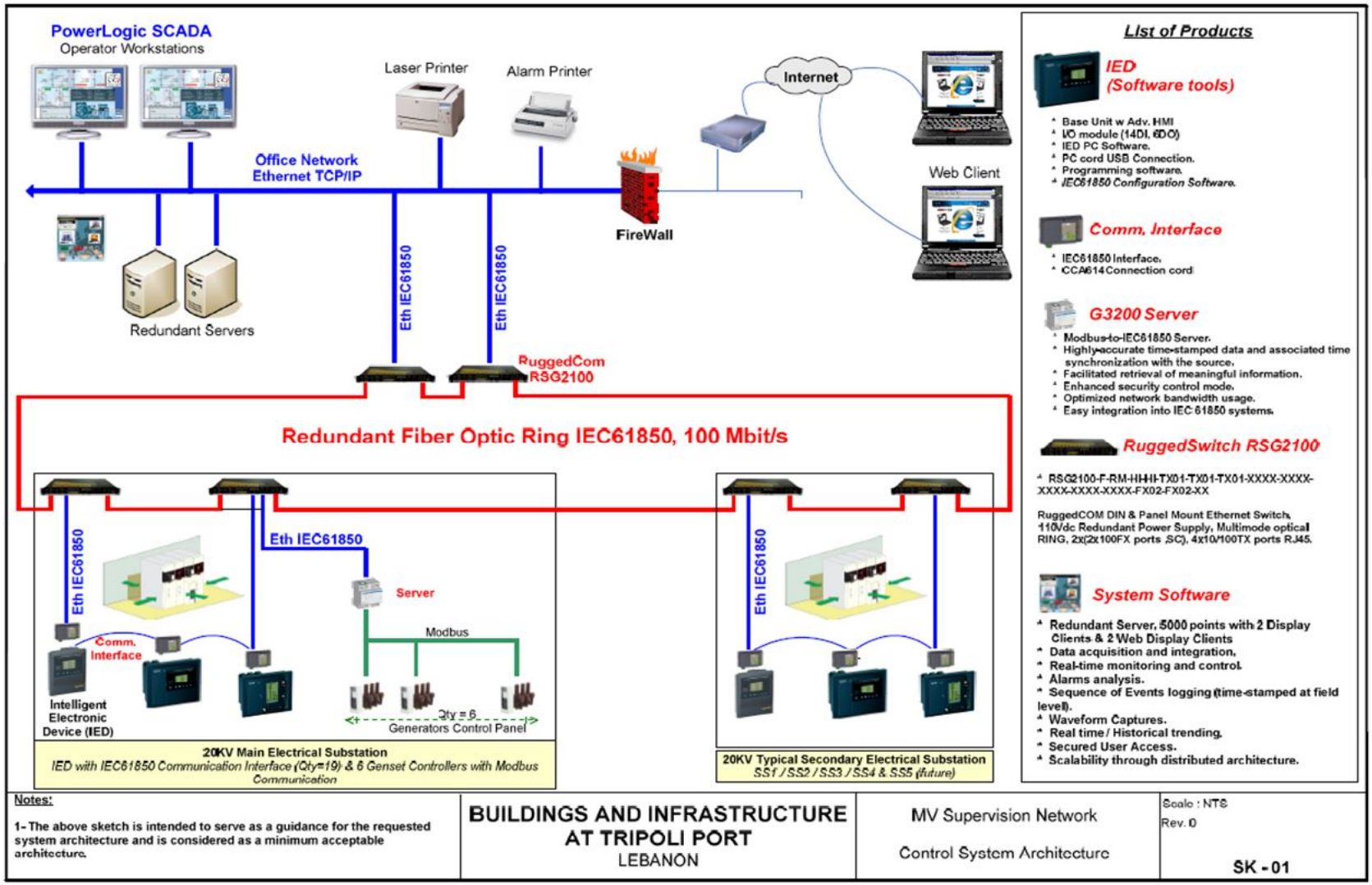
- Power quality, Protection, System,
- Groupings - Currents, Voltage, Power, Power Factor, Energies, Demands, etc.
- Sag/Swell, Over/Under, Transients, Loss, Interruptions, etc.

It shall provide the ability to customize the device types for use on specific customers. This tool shall be an instantiation wizard for the generation of the database for the project. It shall provide the ability to call for a specific device profile. It shall provide then the ability to populate the data base by setting up all the necessary information relevant to the device into the data base.

K260 Communication rings shall be installed inside the Low Current infrastructure network ruinning along the Site.

K265 Contractor to provide complete description for the Engineer's approval based on following block diagram, which represents the minimum requirements for the system.

K270 Training of the Employer personnel is to be included within the proposal.


PowerLogic SCADA
Operator Workstations
Laser Printer
Alarm Printer
Internet
Office Network
Ethernet TCP/IP
FireWall
Web Client
Redundant Servers
Eth IEC61850
Eth IEC61850
RuggedCom
RSG2100
Redundant Fiber Optic Ring IEC61850, 100 Mbit/s
Eth IEC61850
Server
Modbus
Comm. Interface
Intelligent Electronic Device (IED)
Qty = 6
Generators Control Panel
20KV Main Electrical Substation
IED with IEC61850 Communication Interface (Qty=19) & 6 Genset Controllers with Modbus Communication
Eth IEC61850
20KV Typical Secondary Electrical Substation
SS1 / SS2 / SS3 / SS4 & SS5 (future)
List of Products
IED
(Software tools)
* Base Unit w Adv. HMI
* I/O module (14DI, 6DO)
* IED PC Software.
* PC cord USB Connection.
* Programming software.
* IEC61850 Configuration Software.
Comm. Interface
* IEC61850 Interface.
* CCA614 Connection cord
G3200 Server
* Modbus-to-IEC61850 Server.
* Highly-accurate time-stamped data and associated time synchronization with the source.
* Facilitated retrieval of meaningful information.
* Enhanced security control mode.
* Optimized network bandwidth usage.
* Easy integration into IEC 61850 systems.
RuggedSwitch RSG2100
* RSG2100-F-RM-HHHI-TX01-TX01-TX01-XXXX-XXXX-XXXX-XXXX-XXXX-FX02-FX02-XX
RuggedCOM DIN & Panel Mount Ethernet Switch, 110Vdc Redundant Power Supply, Multimode optical RING, 2x(2x100FX ports ,SC), 4x10/100TX ports RJ45.
System Software
* Redundant Server, 5000 points with 2 Display Clients & 2 Web Display Clients
* Data acquisition and integration.
* Real-time monitoring and control.
* Alarms analysis.
* Sequence of Events logging (time-stamped at field level).
* Waveform Captures.
* Real time / Historical trending.
* Secured User Access.
* Scalability through distributed architecture.
Notes:
1- The above sketch is intended to serve as a guidance for the requested system architecture and is considered as a minimum acceptable architecture.
BUILDINGS AND INFRASTRUCTURE AT TRIPOLI PORT
LEBANON
MV Supervision Network
Control System Architecture
Scale : NTS
Rev. 0
SK - 01

## 212:L POWER TRANSFORMERS

### 212:L2 SEALED LIQUID IMMERSED TYPE

L210 TYPE: 3-phase, two-winding, low-loss, liquid immersed, sealed type, rated for continuous operation under site ambient conditions at full rated power, naturally cooled (ONAN) with off-load, manual, externally operated tap- changer, lockable in all positions, on primary side.

L220 STANDARDS: transformer is to comply with IEC 60076, 60156, 60296, and 60404-2.

L230 CONSTRUCTION: variable volume steel tank, with corrugated wall design forming integral cooling pockets, heavy rolled welded steel bottom and base frame and hermetically sealed bolted-on cover. Tank is to be filled with insulating liquid drawn in under vacuum. Cover is to have provision for two thermometers or temperature sensors, lugs for lifting, four lashing lugs and filler-pipe with valve. Tank is to have drain valve at bottom, earthing bolt on cover, earthing pad on base-frame, and rating plate.

L240 BASE FRAME: to have four towing lugs and provision for fringeable flat rim wheels arranged for longitudinal or cross-travel.

L245 TRANSFORMER NO LOAD AND LOAD LOSSES are not to exceed BS EN 50464-1 values for low losses class**.**

L247 NOISE LEVEL A-weighted sound power (LWA)/pressure (LPA) level measured at 1 m in any direction from transformer is not to exceed BS EN 50464-1 values for the specified classes in item above.

L250 WINDINGS: Medium voltage winding is to be copper, and low voltage winding is to be copper unless otherwise approved.

L255 BUSHINGS: to be porcelain, mounted on tank cover, with arcing horns on MV side (if not enclosed). Side bushings for flanged and enclosed connections or plug-in bushings are to be provided for terminal connections as required or as shown on the Drawings.

L260 CABLE TERMINALS, fittings and sealing ends are to be arranged as described in clause L270 hereof and/or as shown on the Drawings.

L265 FINISH: surfaces are to be steel grit blasted, caustic washed and phosphatized, primed with waterproof primer and finished with weather-resistant enamel and final coat of air- drying enamel. Alternative finish may be used subject to approval.

L270 CHARACTERISTICS:

| | | |
|---|---|---|
| rated power (net site rating) | : | as shown on drawings |
| winding connection | : | Dyn 11, neutral insulated & brought out |
| frequency | : | 50 Hz |
| type of insulating liquid | : | mineral |
| highest voltage $U_m$ (rms) | : | |
| MV side | : | 24 kV |
| LV side | : | 0.4 kV |
| rated voltage (no load): | | |
| primary | : | 20 kV |
| secondary (no load) | : | 0.38 kV |
| short circuit impedance at at rated current | : | as per IEC 60076 |
| tap-changer positions | : | 5 positions |
| rated power frequency withstand voltage | : | 50 KV |
| rated lightning impulse withstand voltage | : | 125 kV |
| short-circuit apparent power of system at location | : | 500 MVA |
| duration of short-circuit withstand | : | 2 seconds |
| terminal connections: | | |
| MV side | : | Cable sealing ends |
| LV side | : | Cable glands fittings, bolted from Above |

L280 ACCESSORIES are to include the following:

Digital protective unit for transformer monitoring and protection against gas emission/oil level, oil temperature and oil pressure with thermometer for indication of oil temperature, oil level indicator, 2 N.O. contacts for oil temperature alarm and trip, 2 N.O. contacts for oil level alarm and trip and one N.O. contact for oil pressure trip functions.

Drain valve and sampling device

Flat rim wheels and attachment fittings

Buccholz relay with seperate contacts for alarm and tripping

## FIELD AND INSTALLATION WORK

### 212:1 INSTALLATION

1101 EQUIPMENT BASES: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixings bolts and provisions for passage of cables etc. are provided as required.

1201 CABLE TRENCHES: ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

1401 EQUIPMENT: install on concrete bases etc. and assemble completely plumb and level, before grouting in holding-down bolts.

1701 EARTHING: ensure that earthing installation is in accordance with the requirements of Section 219 of the Specification and/or as shown on the Drawings.

1801 CABLING AND WIRING: install cables, wires, raceways, supports, cable ends and termination fittings in accordance with the appropriate sections of the Specification and/or as shown on the Drawings.

### 212:2 INSPECTION AND TESTS ON SITE

2101 EQUIPMENT: inspect equipment upon delivery to site and report any damage to the Engineer.

2111 SWITCHGEAR: inspect and check switchgear for completeness and as recommended by the manufacturer and check phasing of buses, contact alignment and clearances.

2121 COMPONENTS: check component ratings, types, sizes and wiring connections, including current and voltage transformers, fuses, switches, instruments and relays.

2201 BEFORE ENERGIZATION carry out at least the following tests:

insulation resistance on MV equipment including busbars, bushings, through insulators and feeder terminations, using a 5000 V megger, between phases, and between phase and earth, with control and protection circuit, lamps and similar components disconnected

insulation resistance on every cable and insulator, power, control and relay circuit of the LV systems, using appropriate megger range

HV test, using power frequency HV test set, to 80% of IEC withstand voltage for 1-minute, between phases and phase to earth for each MV switchgear and transformer, disconnected

HV testing of feeder cables and terminations, as appropriate

earth pit resistance and earth loop resistance at substation

contact resistance on switchgear, bus connection and the like, using appropriate micro-ohm meter

polarity and ratio checks on CTs

calibration checks and adjustment on ammeters and voltmeters

primary and/or secondary injection to check relay operation, using appropriate test sets

tripping of circuit breaker, once only, via the protective relay circuits.

power transformer insulating oil test, at nearest laboratory, unless not recommended by manufacturer or not required by the Engineer.

2301 AFTER ENERGIZATION carry out inspection and checking as follows:

close circuit breakers in sequence, load gradually to peak load and observe overheating, using appropriate instruments/sensors

observe overheating of transformer and switchgear and take and record readings bi-hourly for 72 hours

after a prolonged test run, isolate circuit breakers, inspect isolating contacts, and main contacts or contact mechanism whilst slowly closing circuit breaker, and take necessary measurements for comparison with manufacturer's standards.

inspect for loose bolts, switch contacts and the like

follow manufacturer's instructions for testing and commissioning and record all readings.

# 214 STATIC UNINTERRUPTIBLE POWER SUPPLY (UPS) SYSTEM

## 214:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: UPS system installation comprises the following:

Complete rectifier/charger-battery-inverter system with automatic static switch and maintenance by-pass circuit (external bypass for UPS units of rating exceeding 5 KVA),

Interplant power and control cabling,

Connection of normal a.c. power from assigned terminals/switch/circuit breaker, as shown on the Drawings,

Earthing system.

A201 STANDARDS: installation is to comply with relevant IEC, BS, EIA, NEMA and IEEE or equal Standards. Materials and components are to be manufacturer's latest design, and Standards used are to be approved prior to manufacture. Radio frequency interference (RFI) suppression is to be in accordance with CISPR11 recommendations.

A251 NOISE LEVEL of complete assembly is not to exceed 65 dB (A) at 1.0 m distance anywhere within UPS room.

A261 TEMPERATURE LIMITS within which equipment is to be designed to operate are zero to + 40 deg. C at 100 % rated output. Equipment is to be capable of operating under up to 55 deg. C ambient conditions with derating factor of 1.25% per deg. C over 40 deg. C.

A301 EQUIPMENT DATA: submit full technical data of equipment for approval including, but not limited to, the following:

manufacturers' catalogues, detailed description, compliance with the Standards, dimensions and weights, system operation, operating characteristics, methods of operation, protective and control provisions, heat losses, ambient conditions and limitations on electronic components etc. beyond which such components may suffer partial or permanent damage.

A401 TEST CERTIFICATES: submit type test and routine test certificates. System is to undergo a functional and load test program approved by the Engineer, and is to undergo a minimum 72 hours 'burn-in' test, under site simulated conditions, prior to shipment.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Plans and front and side elevations, with indication of built-on control and indicating devices and instruments, exact dimensions and weights, cabling, etc.

One-line diagram with ratings of each piece of equipment, cabling, grounding, etc.

Control and elementary diagrams, wiring diagrams and the like,

Installation and mounting details,

Batteries arrangement and mounting details.

A701 SPARE PARTS: provide manufacturer's recommended spare parts for 1000 hours operation of UPS system. Provide list of manufacturer's spare parts for 2000 hours operation together with current prices.

A751 TOOLS AND INSTRUMENTS: provide tools and instruments required for normal routine inspection, testing, operation and general maintenance, as recommended by the manufacturer.

A901 WARRANTY: provide one year warranty for equipment specified in this Section.

A951 LOCAL REPRESENTATIVE: provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy the Engineer may disqualify a manufacturer.

A981 MAINTENANCE CONTRACT: obtain an undertaking by the equipment manufacturer and his authorized local representative to provide an annual maintenance contract, available after substantial completion of the work, covering routine service and emergency service by trained employees, and to ensure supply of necessary standard spare parts.

PRODUCTS AND SYSTEMS

## 214:H UPS SYSTEM

### 214:H1 SYSTEM DESCRIPTION

H105 SYSTEM: is to be online, of the programmable type, microprocessor based with CPU and memory capabilities for storage of alarms, faults, status change, etc. The UPS shall permit setting parameters for the environment and type of usage to be specified by the Engineer. UPS is to be of the self-diagnostic type, equipped with a self-test function to verify correct system operation. The self test shall identify the parts of the UPS requiring repair in case of a fault. The system shall be provided with multi-password levels to limit access to software and data.

H110 GENERAL: system is to be interposed between normal a.c. power supply and critical load, to secure a minimum period of continuity of no-break battery back-up for 15 minutes in case of failure of normal a.c. supply and maintain output voltage, frequency and phase deviation within specified tolerances.

H120 SYSTEM is to be non-redundant, maintained (continuously supplying load through the inverter), with automatic no- break transfer to or retransfer from alternate source (bypass) in case of failure or overload on rectifier- battery-inverter system.

H130 NORMAL A.C. POWER SUPPLY will be available from one protected source fed from either normal a.c. network or from alternate a.c. normal supply and in-house stand-by diesel generator set as shown on the Drawings.

H155 SYSTEM OVERALL EFFICIENCY is not to be less than 92 % at full load and 91 % at half load.

### 214:H2 SYSTEM OPERATION

H210 UNDER NORMAL CONDITIONS inverter(s) are to be synchronized and phase locked to normal a.c. supply. Upon loss of normal a.c. supply, battery is to continue supply of no-break power to inverters, which then free-run on self- generated UPS frequency reference. Upon restoration of normal a.c. supply, inverters are to re-synchronize to a.c. line, gradually (at slew rate), if frequency and voltage deviation of normal a.c. supply is within preset limits specified.

H230 AUTOMATIC TRANSFER TO BYPASS: static transfer switch is to automatically transfer critical (100%) load from inverter to by-pass source (which is normal a.c. supply) if:

Inverter output voltage characteristics fall outside specified limits,

Critical load exceeds overload rating of UPS,

Over-temperature is sensed,

Manual (push button) command is given.

Transfer to by-pass mode is to be inhibited, and an alarm initiated if voltage, frequency and/or phase shift of by- pass power is outside acceptable tolerances.

H240 RE-TRANSFER TO INVERTER: re-transfer of critical load from auto by-pass source to inverter (UPS mode) is only to be possible under the following conditions:

Inverter output voltage characteristics return to within specified tolerances,

Original load current reduces to within rated full load capacity of UPS,

Re-transfer selector switch is in automatic position.

H250 LOCK-OUT FEATURE is to inhibit re-transfer if by-pass source conditions are outside preset tolerances or if UPS output and by-pass are not synchronized and phase locked or if UPS output is not restored to normal conditions.

H260 NORMAL POWER RESTORED: when normal power is restored following an outage, rectifier/charger is to initially draw no power except for transformer in-rush current. After approximately 15 seconds (walk-in time), input power requirements are to rise to power level to drive critical load and recharge battery.

H270 Provide maintenance disconnecting switch fully rated to carry the full load input current of the UPS.

214:H3 SYSTEM CHARACTERISTICS

H310 RECTIFIER/CHARGER INPUT:

| | | |
|---|---|---|
| Nominal input voltage | : | As shown on drawings |
| Voltage input variation | : | +10%, -15% from nominal |
| Frequency | : | +/-5% from nominal |
| Transformer exciting current in rush | : | less than 600% nominal current |
| Power factor | : | 0.8 lagging at full load and nominal input voltage |
| Total harmonic feedback | : | maximum 5 % (total) |
| Current limiting | : | 115% max. of that required to operate inverters and charge battery at full rated load, adjustment possible between 100% and 125% |
| Walk-in current inrush | : | 25% to 100% FLC in 15 seconds. |

H320 RECTIFIER/CHARGER OUTPUT:

| | | |
|---|---|---|
| Float and equalize operation | : | adjustable, automatic, and compatible with battery |
| Regulation | : | +/-1% max. from 0-100% load |
| Ripple | : | +/-2% rms. (0 to 100 % resistive load) |

H330 STATIC INVERTERS:

| | | |
|---|---|---|
| Net system power output rating, nominal | : | As shown on drawings, with load power factor 0.7-lag to 0.9- lead |
| Nominal output voltage | : | 220 / 380 V a.c. 50 Hz, |
| voltage | : | 1 / 3-phase,<br>2 / 4-wire,<br>adjustable, +/-5% of nominal (as shown on the drawings) |
| Output voltage regulation: | | |
| Balanced load | : | +/-2 % (0 - 100% load) |
| Output voltage waveform | : | 5% max. total harmonic<br>3% max. single harmonic |
| Frequency stability | : | normally synchronized to input line frequency over ±2 % adjustable range; free running at +/-0.5% over full battery voltage variation, load and p.f. range; slew rate not to exceed 0.1 Hz/sec |
| Dynamic output voltage tolerance sudden full load removal | : | +/-10% max. recovering to within 1% in less than 100 milliseconds |
| Overload rating | : | 125% for 10 minutes<br>150% for 60 seconds<br>1000% for 5 cycles<br>105% continuous. |

H340 AUTOMATIC STATIC TRANSFER SWITCH:

| | | |
|---|---|---|
| Transfer time | : | 150 micro-second (overlapping), maximum |
| Total sensing and transfer / retransfer time | : | 2 milliseconds, maximum |
| Retransfer mode | : | automatic/inhibit (selectable) |

| | | |
|---|---|---|
| Retransfer delay | : | 2 - 32 secs. in auto mode (selectable) |
| Transfer point | : | +/-10% of nominal output voltage (adjustable) |
| Retransfer point | : | +/-5% of nominal output voltage (adjustable) |
| Transfer inhibit point | : | +/-20% of nominal output voltage (adjustable) |

214:H4 COMPONENTS AND ACCESSORIES

H405 MATERIALS AND PARTS: electronic devices are to be solid state, hermetically sealed. Indicator lights are to be twin LED type, those denoting blown fuse conditions are to be seen by operator without removing panels or opening cabinet doors. Power connections and remote alarm and control wiring are to be accessible at terminal boards. Power semi- conductors are to be fused. Metal surfaces including copper and aluminium heat sinks and busbars are to be treated with permanent protective coating. Electro-mechanical power devices and relays are to be vacuum impregnated, insulated for maximum operating voltage conditions, and enclosed in dust-tight enclosures. Cables are to be fire resistant high temperature grade.

H408 UPS is to be provided with a socket connection for a serial interface to be linked to a portable PC, to a modem and to the BMS for communication with the UPS when available. It shall enable interrogation of the UPS about status, faults, data stored, reprogramming, etc.

H410 HOUSING: equipment is to be housed in a free-standing, well ventilated, totally enclosed modular assembly with front accessible lockable doors, giving easy access for maintenance, inspection and adjustments, and with provisions for handling and lifting during and after installation. Enclosures are to be suitable for industrial, tropical environments; protection IP 21 to IEC 60947-1 and IEC 60529, of galvanized sheet steel construction treated against corrosion and with light grey RAL7032 baked paint or epoxy finish to approved standard.

H415 SUB-ASSEMBLIES and components are to be mounted on pull- out and/or swing-out trays, of the plug-in type where possible. Where it is not possible to mount components in pull-out or swing-out trays, they are to be easily accessible inside the enclosure. Assemblies shall be replaceable without requiring any adjustments or settings in the UPS.

H420 VENTILATION: for units rated over 5 kVA, an integral, forced-air, cooling system is to be provided in each UPS module to remove dissipated heat efficiently, and ensure components operate within environmental ratings. Air is to enter bottom of cabinet through replaceable filters, and exhaust through the top. At least two fans are to be provided for ventilating each enclosure. No degradation of performance is to occur in the event of a single fan failure. Temperature sensors, mounted on semi-conductor heat sinks, are to initiate alarm if maximum working temperature is exceeded.

H425 RECTIFIER/CHARGER UNIT is to have mainline circuit breaker and two-winding dry-type, Class H insulated, class B temperature rise, with metallic electrostatic shielding, high efficiency (98%), regulating transformer and is to be automatic with soft start-up (walk-in) feature, using silicon controlled rectifiers (thyristors) with control logic circuitry to control firing angles to thyristors to suit power output requirements and protect against primary power surges, lightning transients, under-voltage and over-voltage conditions. Output is to be passed through LC filters to d.c. bus.

H427 RECTIFIER/CHARGER UNIT is to be capable of supplying full load power to inverter, and to charge the battery from a discharge condition to 95% charge within ten times discharge period, and maintain full charge at floating voltage until next operation. Charger current is to be voltage regulated and current limited. Where three-phase supply is involved, rectifier is to be at least six-pulse type for UPS ratings up to 80 kVA, and 12-pulse type for 80 kVA ratings and above.

H430 INVERTER is to employ Insulated Gate Bipolar Transistors (IGBT) technology in three leg, pulse width modulation (PWM) design with high frequency switching technique, and complete with output transformer and filters. Inverter start-up is to be automatic, to reach full voltage within milliseconds and deliver power to the load within 2 seconds. Inverter is to start at any load including short-circuit. Output transformer is to be two-winding dry-type, Class H insulated, class B temperature rise, with metallic electrostatic shielding, high efficiency (98%).

H435 INVERTER OSCILLATOR is to operate and maintain output frequency of inverter within specified tolerances, and be capable of synchronization and phase-locking to normal power supply frequency. When inverter is phase-locked to normal power supply, and latter fails, oscillator is to automatically revert to free running state (quartz oscillator) and maintain specified limits.

H440 AUTOMATIC STATIC TRANSFER SWITCH is to be continuously rated at full load (100% FL), hybrid type (make-before-break), solid state transfer device with logic thyristor assembly isolatable or completely withdrawable for maintenance. When signal to close switch is initiated, thyristors are to instantaneously conduct power to prevent deviations and breaks in load voltage outside specified tolerances.

H445 MAINTENANCE BY-PASS SWITCHING: manual (make-before-break) by-pass switch is to allow load to be transferred to by-pass source without interruption of output, and provide isolation of UPS and static switch during maintenance. Test position is to permit testing of static switch while load is being fed from bypass power circuit. Transfer inhibited warning circuit is to be provided to give an alarm indication in case by-pass supply is beyond acceptable tolerances.

H450 PROTECTION: UPS modules are to have built-in or inherent electronic current-limiting protection against permanent self damage effective down to short-circuits. Fast acting, current limiting devices are to protect against failure of any solid state component. Internal failure in any UPS module is to cause immediate isolation from input and output by operation of static interrupters or causing shut down of faulty module. Protection is to be provided against, but is not limited to, the following:

- Input over and under voltage and power line surges,
- Output over voltage and voltage surges,
- Sudden abnormal changes in output load conditions,
- Short-circuits at output terminals,
- Inverter and rectifier overcurrent,
- Auxiliary control circuit overcurrent.

H452 UPS OUTPUT NEUTRAL: is to be designed to continuously carry twice the full load phase current.

H454 INPUT FILTER DISCONNECTION: UPS control system is to disconnect the input filters in case of interruption of utility power supply failure while the UPS is operating at light loads (less than 25%).

H455 BATTERY: built in, high rate discharge, heavy duty, industrial, high impact resistant, clear plastic encased, sealed lead- acid (gas recombination) type cells with automatically reclosing explosion proof safety vents. Electrolyte specific gravity is not to exceed 1.25 when fully charged at 25 deg. C. Ampere-hour rating is to be sufficient for emergency period specified with all inverters operating at full rated output, to a discharge limit of not less than 1.65 V per cell. Cells are to be normally maintained at 2.25 V per cell. Guaranteed life is not to be less than 10 years, with a capacity drop down to not less than 80% under normal expected service.

H465 MIMIC PANEL: UPS assembly is to include a mimic diagram with digital and LED displays, indicating instruments and control devices, in true relative positions.

H470 LOCAL PANEL INSTRUMENTS are to include at least the following (digital readings):

- Inverter input voltmeter, measuring d.c. bus volts,
- Battery ammeter, measuring charge/ discharge current,
- a.c. voltmeter to measure inverter output voltage, normal supply voltage or system output,
- UPS output ammeter and frequency meter.

H475 LOCAL PANEL INDICATORS are to include at least the following:

- System on battery supply,
- Inverter phase locked to verify synchronization between inverter output and normal a.c. supply input,
- Static switch on normal a.c. supply (bypass mode),
- Static switch inhibited,
- Over-temperature, indicating excessive temperature in heat sinks for transformers, rectifer/charger and inverter (alarm to automatically transfer load to by-pass circuit),
- Inverter output overload, indicating inverter output beyond specified rating failure of any stage, d.c. bus earth fault, inverter output earth fault.

H480 LOCAL BUILT-IN CONTROLS are to include at least the following:

- Inverter on/off,
- Battery input circuit breaker,
- Auto/manual reset-test switch,
- Manual reset switch,
- Hybrid switch transfer test push-button,
- Re-transfer auto/inhibit selector switch to allow automatic re-transfer of load to inverter after timed interval of normal operation and inhibit re-transfer of load to inverter until hybrid switch is in auto-mode,
- Battery automatic/equalize recharge timer, 0-30 hours adjustable, with automatic/boost/equalize switch (accessible to maintenance personnel only and to be used only with manufacturer's recommendation for type of battery specified),
- Voltage and frequency adjustment controls with locking devices (accessible to maintenance personnel only),
- Indicator test/reset switch,
- Control power supply isolator (accessible to maintenance personnel only),
- Alarm test-accept-reset.

H485 LOCAL BUILT-IN ALARMS causing horn to sound, with tripping command if required, are to include at least the following:

- Fan failure: alarm only,
- Over temperature: alarm with automatic transfer of load to by-pass after a safe preset period,
- d.c. volts out of limits: alarm with indication,
- Fuse failure: alarm,
- Battery on load/disconnected: alarm only,
- Overloads: alarm only with a trip command if pro- longed, for each rectifier/inverter unit,
- Normal a.c. supply failure: alarm only,
- Hybrid switch operation to by-pass mode: alarm only,
- Low and high output voltage: alarm only.

## FIELD AND INSTALLATION WORK

### 214:1 INSTALLATION

1101 EQUIPMENT BASES: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are provided as required.

1151 BUILT-IN ITEMS: ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases or building structure are provided as and when required and that they are properly installed.

1201 TOOLS: use only tools recommended by equipment manufacturers for installations, particularly in making connections and adjustments.

1231 EARTHING: provide direct interference free earthing circuit in accordance with Section 219 of the Specification.

1251 SUPERVISION: carry out equipment installation under the direct supervision of a qualified technician, licensed by and trained at the factory. Final adjustments and putting into satisfactory operation are to be made by a specialist delegated by the factory.

214:2 TESTS ON SITE

2101 POWER SUPPLY OUTPUT DISTURBANCE: provide microprocessor based instrument, and monitor and record power supply output disturbance of voltage and frequency. Instrument details are to be submitted for approval.

2201 TEST PERIODS are to be prolonged (over 24 hours) and as requested by the Engineer, to verify and obtain realistic voltage and frequency profile under any loading and switching conditions within the criteria specified.

2301 DATA LOGGING is to include high and low average voltage, sags and surges, spikes and spike bursts, drop-outs; high and low frequencies etc. with print-out and storage on cassette tape for subsequent re-entry into instrument's memory for display or print-out.

2401 TESTS are to include loads at various power factors from low-load to overload condition, and measurements of temperature, heat losses, output voltage, wave shape, and harmonic content and frequency stability.

# 215 MAIN DISTRIBUTION BOARDS

## 215:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: main distribution board(s) (MDBs) for low voltage (LV) distribution, ancillary mounting frames, fittings, cable termination accessories and supports, including relays, transducers, wiring, etc. as detailed in the Mechanical Specifications and/or shown on the drawings.

A201 STANDARDS:

Switchgear and control gear are to comply, as a minimum, with IEC 61439-1 “Low-voltage Switchgear and Control Gear Assemblies”.

IEC 60947-1 Low Voltage switchgear and controlgear, Part 1: General Rules.

IEC 60947-2 Low Voltage switchgear and controlgear, Part 2: Circuit Breakers .

Other components, where not otherwise specified, are to comply with the relevant IEC standards.

IEC 60831 – 1 & 2. Shunt Power capacitors for power factor correction.

A301 EQUIPMENT DATA: submit for approval detailed description of main distribution boards including all components supported by manufacturer's catalogues, indicating compliance with the Standards, equipment characteristics, details of construction, operating data, dimensions and weights etc. Give details of miscellaneous items including incoming and outgoing feeder terminal arrangement, connections at busbars, isolating, earthing, interlocks, control devices, indicating and metering instruments etc. Boards are to be factory assembled and tested and shipped as complete package (s).

A401 TESTS AND CERTIFICATES: submit complete certified manufacturer's type test (TTA) and routine test records, in accordance with IEC61439 requirements for type tested and partially type tested Switchboards.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Plans and elevations with indication of built-on equipment, exact dimensions and weights,

Arrangement of boards inside rooms allocated, indicating spaces and clearances,

Arrangement of equipment inside board,

One-line diagram of power system showing current ratings of switchgear and busbars and types and locations of protective gear (relays, instruments, CTs, VTs etc.),

Schematics and wiring diagrams of control circuits,

Foundation details, grouting holes, installation details,

Arrangement of incoming and outgoing feeders, terminal fittings, instruments, busbar connections, etc.

Mimic-bus diagram.

A601 TECHNICAL LITERATURE: submit the following for approval prior to placing orders for equipment manufacture:

Schedule of circuit breakers application, indicating type, range, features and characteristics, short-circuit ratings, time-current curves, etc.

Method of setting of protective devices for overload, short-circuit and earth-fault currents as coordinated with upstream and downstream systems based on specific coordination curves of protective devices used and specific calculated prospective short-circuit currents at various points,

Test methods on site and references, including testing equipment for microprocessor controlled trip units.

A701 SPARE PARTS: provide manufacturer's recommended spare parts for emergency replacement and/or one year's maintenance including, but not limited to, the following:

One set of fixed and moving contacts for every type of replaceable (consumable) contact set,

One operating motor and/or coil for each type of electrically operated circuit breaker,

Two sets of each type of indicating lights, fuses, LED’s, etc.

A702 TOOLS AND INSTRUMENTS: provide tools and instruments for normal routine inspection maintenance and testing of circuit breakers and protective devices as appropriate for type of switchgear and control gear supplied.

A703 COORDINATION STUDY: Contractor is to submit a complete coordination and protection study for all the electrical system. The coordination shall be fully detailed to show the short circuit currents at each panel location. The study shall show that the protective devices provided do ensure the proper protection and coordination. Any breakers not satisfying the study shall be replaced by proper ones to ensure proper system operation. The coordination study has to be associated with a coordination study for earth fault currents throughout the system to ensure proper selection of earth fault setting for all breakers to ensure discrimination and proper protection of all system components.

## PRODUCTS AND SYSTEMS

### 215:X MAIN DISTRIBUTION BOARDS AND ACCESSORIES

### 215:X1 GENERAL REQUIREMENTS

X105 GENERALLY: main distribution boards are to be dead-front type, metal enclosed, multi-cubicle, floor mounted, free standing, with 1000V rated insulation voltage, and 600 V rated operational voltage, with fixed or draw-out switchgear, manually or manually and electrically operated, as specified and/or shown on the Drawings, with matching vertical sections to form a continuous integral and rigid structure. Outgoing sections are to be of equal width. Cable entrances to be as shown on drawings.

X107 GENERALLY: Contractor shall coordinate with other systems, whereqapplicable, and provide all necessary interfaces, relays, transducers, RS232, ethernet connection, etc.

X110 GENERAL CONSTRUCTION: rigidly framed and bolted, with electro-galvanized sheet steel enclosures, minimum thickness 1.5 mm, phosphatized, primed with rust inhibiting primer and finished with thermal polymerized polyester epoxy powder coating, gray colour (RAL 7703 or ANSI 61) to approval. Switchgear is to be vermin, dust and rodent proof, IP42 protection to IEC 60947-1 and 60529 for indoor installations, with adequate lifting means and base-frames and capable of being moved into position and directly bolted to floor without additional sills.

X115 VENTILATION: compartments are to be ventilated, by approved methods complying with the Standards.

X117 MAIN DISTRIBUTION BOARDS are to have a minimum short circuit withstand current rating 25% higher or next available standard to the calculated short circuit at respective point of application in the network, for a short circuit duration of 1 sec to the approval of the Engineer.

X120 FASTENINGS between structural members are to be bolted.

X125 EXTENSION of structure and busbars is to be possible at either end of switchboard for form 3 type switchboards.

X130 ARRANGEMENT is to permit incoming and outgoing busbars and cables to enter enclosure as indicated on the Drawings and connect at respective terminals without inconvenience to installation or maintenance.

X135 REMOVING CIRCUIT BREAKERS: suitable arrangements and equipment are to be provided for extracting, lifting and unloading switchgear from enclosures as appropriate for type of switchgear.

X140 SPARE AND SPACE POSITIONS are defined as follows:

spare position : fully equipped enclosure with switchgear,

space position : fully equipped enclosure ready to receive switchgear.

X145 BUSBARS: to be site rated for normal current as shown on the Drawings or at least site rated to same rating of main circuit breaker frame size, and braced for a symmetrical rms short-circuit duty as specified. Busbars are to be copper, of sufficient size to limit temperature rise to allowable insulation or equipment temperature ratings, and to a total maximum temperature of 90 deg C. Connections and buswork are to be bolted with copper alloy hardware and are to be accessible for inspection and maintenance unless otherwise recommended by the manufacturer and approved by the Engineer. Contact surfaces are to be electro-silver plated.

X150 CONNECTIONS from busbar to switchgear are to be rated to carry full continuous current rating of switchgear frame and are to be insulated.

X155 FULL SIZE NEUTRAL is to be continuous through all sections. Neutral bus is to be insulated and separate from earth bus and connected to it with removable links, at every bus section. Links are to be of the same cross-section of the earth bus.

X160 EARTH BUS is to extend full length of board, firmly fixed to each section in accordance with the Regulations and Standards, complete with two main earthing lugs (one at each end), and required number of feeder protective earth connectors.

X162 EARTH BUS is to be half size of phase buses

X165 SWITCHBOARD TYPE: switchboard(s) are to be of the following type(s):

Form 3a to IEC 61439.

Incoming: Withdrawable PACB type.

Outgoing: Fixed MCCB type, unless otherwise shown on the drawings.

Refer to drawings for each assembly and its particulars of incoming and outgoing breakers where applicable.

X170 WITHDRAWABLE METAL ENCLOSED CIRCUIT BREAKER SECTION is to consist of compartmented unit(s), stationary part with rear busbar and cable connection compartments and front draw-out circuit breaker assembly. Partitions between sections are to be bolted steel plate and partitions between compartments are to be tough solid insulating removable bolted barriers. Each unit is to have hinged lockable front door with grip-handle and door mounted instrumentation.

X175 DRAWOUT CIRCUIT BREAKER ASSEMBLY is to have disconnecting contacts, wheels and interlocks to prevent connecting or disconnecting circuit breaker unless in the open position, and to prevent closing circuit breaker while racking into any of the three positions (connect, test, disconnect). Racking mechanism and rail assembly are to be approved worm and lever mechanism. It is to be possible to close the unit door with breaker in any of the three positions and when removed. External position indicator is to be provided. Fixed disconnecting primary contacts are to be accessible and replaceable from front and are to be silver plated copper. Moving primary disconnect contacts are to consist of self-aligning, silver plated, spring pressure, finger-cluster, copper contact fitted on line and load studs of circuit breaker.

X180 MAIN CIRCUIT BREAKER SECTION is to individually accommodate main circuit breaker, main cable entry with terminal fitting assembly and metering compartment. Where placed against a wall, accessibility is to be possible from front and sides or only from front of section.

X183 PULL SECTIONS: An additional cable pull section is to be provided, depending on actual configuration shown on the Drawing, and subject to Engineer’s approval.

X195 FRONT AND REAR ACCESSIBLE, FRONT AND REAR ALIGNED, INDIVIDUALLY MOUNTED FIXED MCCB DISTRIBUTION SECTIONS as basic construction for form 3 switchboards, are to be compartmentalized construction, consisting

of front modular circuit breaker compartments, busbar system compartments and rear cable termination compartments, with insulating barriers between front compartments and busbar compartments and between rear compartments and busbar compartment (removable for maintenance). MCCBs are to be closely coupled to busbars (to minimize chances of bus-side faults), and to rear cable terminals, through compatibly frame-sized insulated connectors. MCCB modules are to be covered on the front, by recessed frame-type bolted covers, 1.5 mm minimum thickness, to protect circuit breaker handles. Top, sides and rear are to be covered with removable screw-on plates having formed edges all around.

## 215:X2 POWER AIR CIRCUIT BREAKERS (PACBs)

X205 TYPE: encased in high strength, high temperature resistant, moulded plastic insulating materials, for normal operation at maximum temperature within enclosure at point of application, tested to approved standards, manually operated for normal functions, and automatically tripped under overcurrent conditions. Trip power is to be derived from main power circuit, with sufficient tripping energy to reliably trip circuit breaker. Fixed mounted circuit breaker is to be rear connected.

X215 CONSTRUCTION: manually or manually and electrically operated, as shown on the Drawings, with two-step, spring charged, stored energy mechanism, quick-make, quick-break type, electrically and mechanically trip-free, to prevent maintaining circuit breaker closed against overcurrent condition whether under manual or automatic operation. Electrically operated circuit breakers are to have integrally mounted, spring charging motor mechanism automatically recharged upon closing. Both manually or manually and electrically operated circuit breakers are to have mechanical built-in charging lever and are to include open and close direct acting push buttons. Stored energy provision is to allow open/close/open sequence of operation without use of external energy. Circuit breaker is to have arc-quenching devices, one on each pole, and replaceable arcing contacts.

X220 CONTROL POWER: for electrically charged circuit breaker and/or for shunt trip device, where required, control power is to be 120V ac obtained from in-built MDB control power transformer connected and fused on line-side of circuit breaker. Where shunt trip and/or under voltage release are required, a sufficient capacitor trip device is to be provided.

X225 RATING: 3-pole, unless otherwise shown on the drawings. 750 V rated insulation voltage, 600 V rated operational voltage, with continuous current rating (frame size) as shown on the Drawings, ranging between 1600 and 5000 A (1600, 2000, 2500, 3000, 4000 A and 5000 A), fully rated (100%) for service under worst site conditions. Breakers are to be rated for a symmetrical rms service short-circuit breaking capacity as shown on the Drawings, to IEC 60947-2 sequence II (rated service short-circuit breaking capacity) at specified voltage and frequency, meeting IEC 60947-2, sequence I, II, III and IV tests (for circuit breakers of utilization category B), tested in an enclosure substantially the same as the enclosure in which they are to be installed.

X230 TRIP UNIT: to be totally enclosed, programmable, solid state device, interchangeable for compatible frame sizes, pluggable into front of circuit breaker, tamper-proof and with transparent, sealable cover. Trip unit is to measure sinusoidal and non–sinusoidal current wave forms (fundamental to thirteenth harmonic) by continuously sampling each phase through out every cycle. Trip unit is to be direct acting trip device, current transformer operated, with flux transfer shunt trip that requires no external power. It is to have adjustable current setting (0.5 - 1.0 times trip unit rating) with adjustable long-time delay, short-time pick-up and short-time delay, earth-fault pick-up and time delay instantaneous over current pickup. Current setting range is to be by means of replaceable trip-units within the maximum frame size rating. Once removed, circuit breaker is to remain in the trip-free position. Earth-fault trip is to be adjustable, range 10% to 60% of normal current rating of the circuit breaker and a maximum of 1200A, with adjustable time delay between 0.1 and 0.5 seconds. Short time delay is to be adjustable in steps, 2 - 9 times current setting, with pre-settable or adjustable time band having maximum delay of 0.3 to 0.5 seconds. Instantaneous trip is to be adjustable in steps at least 2 – 13 times the trip unit rating. Over-ride protection is to allow full sensitivity up to interrupting capacity of circuit breaker.

X232 TRIP UNIT: shall have in addition to above, metering and protection functions as listed below:

**Metering:**

- phase currents,
- voltage-line to line and phase voltges,
- frequency,
- energy, kWh’s
- total power,( kW), and kVAR,
- peak power demand.

**Protection:**

- over voltage,
- voltage unbalance,
- current unbalance,
- and reverse power.

X234 TRIP UNIT STATUS DISPLAY: shall indicate in words the status of normal breaker operation, long time over current pick up, instantaneous time over current trip, short time over current trip, ground fault trip. Unit shall have integral resetable counter to count long time, short time, instantaneous and ground fault trips.

X235 POSITION INDICATORS: to be positive with trip indication target. Target indicator is to be mechanical and is to give indication even when control power has been lost.

X237 TRIP UNIT shall have inputs from conventional potential transformers for every phase and current sensor (transformer) for every phase. Current sensors shall be encased in epoxy filled plastic housing to protect against damage and moisture and are to be integrally mounted within the circuit breakers.

X238 Where required, ethernet interface shall be provided on breakers for communication with BMS system, including remote monitoring and control capabilities.

X239 NEUTRAL CURRENT TRANSFORMER: is to be provided on the neutral conductor of each main, tie or outgoing circuit having earth fault protection. Rating and characteristics of the neutral current transformer are to be suitable for proper operation of the earth fault protection system.

X240 CIRCUIT BREAKER ACCESSORIES are to include the following:

- Padlocking or keylocking provisions for all positions (disconnected, test, connected, closing blocking, open),
- Overload, short-circuit, and ground fault trip LEDS,
- Trip indicator and reset button,
- Operations counter,
- On/off pilot lights,
- Shunt-trip coil closing solenoid for remote control,
- Bell alarm for remote over-current trip indication.

X245 AUXILIARY CONTACTS: to include N.O. and N.C. contacts on switchgear as required for remote monitoring and control, plus 2 N.O. and 2 N.C. spare contacts.

X250 ELECTRICAL INTERLOCK: if electrical interlock is required between power air circuit breakers (as shown on the drawings), the mechanical closing button of the circuit breaker is to be disabled in the connect position and an additional electrical push button is to be provided for the closing of the circuit breaker through the breaker's shunt close coil. The electrical interlock is to be provided on both shunt trip and close coils of the circuit breaker in order to perform simultaneous tripping and inhibit closing functions on the interlocked breaker(s).

## 215:X3 MOULDED CASE CIRCUIT BREAKERS (MCCBs)

X305 MCCBs GENERALLY are to be electronic solid-state trip type. All circuit breakers are to be 3-pole unless otherwise shown on drawings.

X310 CONSTRUCTION: totally enclosed, moulded case, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at 70 deg. C within enclosures, to approved standards, provided with quick-make, quick-break, trip-free switching mechanism manually operated by front toggle type handle and automatically tripped under overcurrent conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Contacts are to be non-welding silver alloy with arc quenching metallic devices of approved construction. Cable terminals are to be solderless anti-turn box lug or clamp type with set screws suitable for copper or aluminum cables.

X311 MCCB shall be of such a design to accept various types of remote and automatic control devices for operation under a control/logic system and/or the BMS, when available

X330 ELECTRONIC TRIP CIRCUIT BREAKERS are to have solid state trip units with long time delay setting range at least between 0.5 and 1.0 times maximum trip rating, short time delay range 3 to 10 times maximum trip rating with maximum clearing time of 0.2 seconds, and instantaneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between -20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, and is to be adjustable between 0.2 and 0.6 normal phase current pick-up with maximum time delay of 0.2 seconds, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.

X335 TRIPPED POSITION: when tripped automatically by over current condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.

X340 INTERCHANGEABLE TRIPS: circuit breakers 150/160A up to 630 A frame sizes are to have interchangeable electronic trip units.

X350 CIRCUIT BREAKER RATINGS are to be non-current limiting, fully rated (100%) with continuous duty at site conditions 690 V rated insulation voltage, and with frame size and interrupting capacity to IEC 60947-2, sequence II (rated service short-circuit breaking capacity), and maximum trip rating as shown on the Drawings. Interrupting capacities at specified voltage and frequency are to meet IEC 60947-2 test seqeunce I, II, III and IV for circuit breakers of utilization category B (with intended short time withstand capability) for breakers 400A and above, and utilization catergory A for breakers below 400A.

X355 ACCESSORIES: circuit breaker design is to allow addition of electrical operator, control and interlocking functions, under-voltage release, shunt-trip coils, alarm and auxiliary switches, padlocking devices, key-lock devices, and the like.

## 215:X4 METERING INSTRUMENTS & INSTRUMENT TRANSFORMERS

X440 CURRENT TRANSFORMER (CT): indoor dry type, rated secondary current 5 A. Rated primary current, core size and accuracy are to be determined in accordance with nominal current of plant protected, short-circuit level and burden.

X450 VOLTAGE TRANSFORMER (VT): to be provided where required, complete with primary and secondary fuses and disconnecting device.

## 215:X5 MICROPROCESSOR BASED METERING AND MONITORING UNIT

X505 GENERAL: a microprocessor based metering unit is to be capable of monitoring, displaying and communicating the functions listed below.

X510 DIRECT READING METERED VALUES are to be displayed by the unit as follows:

- AC amperes in each phase, +/-0.5% accuracy,
- AC voltage, phase to phase, phase to neutral, +/-0.5% accuracy,
- Kilowatts, +/-1% accuracy,
- Kilovars, +/-1% accuracy,
- Kilovoltamperes, +/-1% accuracy,
- Power factor, +/-2% accuracy,
- Frequency, +/-0.1 Hz accuracy,
- Kilowatt demand (5,10,15,30 minute interval field programmable), +/-1% accuracy,
- Kilowatt hours, Kilovar hours and KVA hours, +/-1% accuracy,
- %THD , +/- 1%

X530 CONTROL POWER is to be drawn from the monitored incoming AC line terminal connections. Device is to have non-volatile memory and not require battery backup. In the event of a power failure, the device is to retain preset parameters.

X540 UNIT is to allow user to disable undersired values or functions and to later reactivate them if required. In the event of trip or alarm condition, a built-in reset button is to allow a manual reset of the unit. Unit is also to be capable of being remotely reset via its communication port.

X550 ADDRESSABLE COMMUNICATION CARD is to be provided, capable of communicating all data, monitoring and control, with the BMS as described in detail elsewhere..

## 215:X6 POWER FACTOR (PF) CORRECTION

X605 GENERALLY: multi step automatic PF correction system is required to bring up power factor of LV system to better than 0.90.

X610 LOCATION OF CAPACITOR BANK is to be indoors, as close as possible to or within nominated switchboard requiring PF improvement, and to be totally enclosed in sheet metal cabinets with appropriate ventilation and minimum IP31 degree of protectin to IEC 60529

X615 CAPACITOR BANK is to be prefabricated, complete with capacitors, contactors, busbars and power factor regulator, to effect automatic control and sensing of power factor for switching in and out the number of steps required to improve PF to at least the figure indicated above, and discharge resistors to enable discharge of capacitors after disconnection.

X620 STEPS are to be rated at maximum 25 kVA, unless approved by the Engineer, 3-phase, operating for loads between 100 kVA and 2000 kVA having PF below 0.85 (refer to the Drawings for total rating and configuration). Selection of the unit steps is to be related to the load without causing abrupt changes in capacitance, nor causing a capacitive circuit load at any load condition.

X630 CAPACITORS are to be dry-type, operating on rated low voltage, made of metalized polypropylene (self-healing dielectric) foils coated with thermosetting resin, or equal construction, proved in operation for at least 5 years, under prevailing ambient conditions. Capacitors are to comply with IEC 60871-1 and IEC 60831-2 or approved equal standards with a loss factor not exceeding 0.3 x 10(-3) (a consumption of about 0.4 watts per kVAr).

X633 SWITCHING OF CAPACITORS is only to be performed by the fast closing contactors on capacitor bank units (with surge limiting reactors as necessary). Switching arrangement of capacitors is not to allow excessive transient capacitive switching at source, i.e. circuit breaker feeding the bank.

X635 ANTI HARMONIC REACTORS are to be provided in series with the capacitors and properly tuned to limit the harmonic currents in order to avoid over loading the capacitors. The reactor rating at 50 Hz is not to be less than 7% of the capacitors to be protected.

X640 ACCESSORIES: each capacitor is to have its own connection terminals, HRC fuses, contactor, indicator lamp and set of discharge resistors.

X650 REGULATOR is to be housed in front door of one cubicle, and is to have setting knob for PF selection between 0.8 and 1.0, manual control position, and signal lights. Regulator controls are to be solid-state, microprocessor-based controls, including the following:

- Under voltage relay that interrupts capacitor switching and disconnects capacitors for power supply interruptions longer than 15 minutes,
- "Advance" and "Retard" push buttons on the control panel to permit manually controlled capacitor-bank switching,
- Three pole contactors rated for the repetitive high-inrush-switching duty in the capacitor application,

- Plated copper buses,
- Fuses for protection of capacitor banks rated to protect contactor, interconnecting wiring, and capacitors,
- Air-core-type inductors connected in capacitor circuits; rated to limit switching surges to within contactor ratings,
- Mechanical bracing for current carrying parts adequate to withstand the maximum fault current to which they may be exposed,
- LED indicating lamps on front panel, to identify the energized capacitor banks,
- Hinged door with hand-operated catch and interlocked with controls or main circuit breaker to de-energize capacitors when door is opened,
- LED or liquid crystal digital type display unit mounted in the enclosure door,
- Current Transformer if required.

X665 CAPACITOR-BANK FUSES: Current limiting, non-interchangeable type; factory installed in each phase and located within the equipment enclosure. Interrupting capacity is to be 200,000 A minimum.

X680 FIXED CAPACITORS: are to be integrally fused, unless otherwise indicated. Internal Wiring is to be factory made, ready for field connection to external circuits at a single set of pressure terminals.

215:X8 WIRING

X805 ARRANGEMENT: wiring is to be modularly and neatly arranged on master terminal boards with suitable numbering strips and appropriate cartridge type fuses where required.

X810 CONNECTIONS are to be made at front of terminal board and with no live metal exposed.

X815 METAL CASES of instruments, control switches, relays etc. are to be connected, by bare copper conductors not less than 2.5 mm2 section, to nearest earthing bar.

X820 CONTROL WIRING: copper, PVC insulated, 85 deg. C, 600 V grade, and PVC sheathed for multi-core cables. Finely stranded copper conductor, silicon rubber insulated cables are to be used where fixed in proximity to higher temperature components or as flexible cable.

X825 FERRULES: wires are to be fitted with numbered and coded ferrules of approved type and design at each termination.

215:X9 MISCELLANEOUS

X950 ANTI-CONDENSATION HEATERS with disconnect switch and pilot lamp are to be provided in each cubicle or panel of the switchboard, controlled by thermostat and/or hygrostat.

X980 SCHEMATIC AND WIRING DIAGRAM is to be provided suitably located within each cubicle.

FIELD AND INSTALLATION WORK

215:1 INSTALLATION

1101 EQUIPMENT BASES: ensure that concrete bases and foundations provided for installation of equipment are constructed in accordance with approved shop and construction drawings and equipment manufacturers' drawings and that holes for fixing bolts and provisions for passage of cables etc. are furnished as required.

1201 CABLE TRENCHES: ensure that trench construction and covers provided for installation of power and control cables are in accordance with approved shop and construction drawings.

1301 BUILT-IN ITEMS: ensure that equipment supports, fixings and the like, and sleeves for passage of feeders and cables which are to be built into concrete foundations, bases, cable trenches or building structure are provided as and when required and that they are properly installed.

1401 EQUIPMENT: install on concrete bases etc., and assemble completely plumb and level, before grouting in holding-down bolts.

1501 SUPPORTS AND TERMINATIONS: install all incoming and outgoing cable supports, cable ends and termination fittings required for power and control cables.

1601 RELAYS: set in accordance with manufacturer's instructions and in accordance with an approved scheme.

1701 MAKE GOOD damaged painted surfaces, clean and apply rust-inhibiting prime coat and two finishing coats of approved enamel upon delivery of equipment to site, or as required by the Engineer.

## 215:2 INSPECTION AND TESTS ON SITE

2101 EQUIPMENT: inspect equipment upon delivery to Site and report any damage to the Engineer.

2111 SWITCHGEAR: inspect and check switchgear for completeness, component ratings, types, sizes, and wiring connections. Check phasing of busbars, contacts and clearances.

2151 TESTS: after installation and before handover, carry out all visual and mechanical inspection and electrical tests required by the governing codes and any other tests the Engineer may require to check compliance of installation with the Specification, including, but not limited to, the tests listed below. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest. Tests are to include:

- Insulation resistance tests for each main distribution board bus, component, connecting supply, feeder, and control circuit,
- Continuity tests of each circuit,
- Operational tests.

2152 PRIOR TO ENERGIZATION OF CIRCUITRY: check all accessible connections to manufacturer’s torque tightening specification.

2201 MAIN AND CONTROL CIRCUITS: using 1000 V megger (2000 Megohm range), check insulation resistance between phases, between phases and earth/enclosure and between neutral and earth.

2251 PRIMARY INJECTION TESTS: provide portable test equipment to test time-delay characteristics of circuit breakers by simulating an overload or fault condition. Measure and record all test results and ambient conditions and compare with manufacturer's data.

2301 INSTANTANEOUS TRIP ELEMENTS: test by high current primary injection, using high-current primary injection test-sets and reports all readings.

2401 ROUTINE TESTS ON SITE are to be carried out on every main distribution board in accordance with the Standard specified (IEC 61439-1 ) whether it is a factory built assembly (FBA) or assembled from standardized components outside the works of the manufacturer.

2410 INSPECTION AND TESTING OF POWER FACTOR CORRECTION :

- Testing Agency: Engage a qualified independent testing agency to perform field quality-control testing.
- Manufacturer's Field Service: Engage a factory-authorized service representative to inspect automatic power factor correction equipment installation and connections. Report results in writing. Include the following: Operational Test: After electrical circuits have been energized, connect and observe units to confirm proper operation.
- Replace damaged and malfunctioning controls and equipment.
- Inspection: Perform external and internal inspections of capacitor equipment for damage and for compliance with the Contract Documents and manufacturer's documentation. Check electrical and mechanical bolted connections for required torque.
- Testing: Perform the following and certify compliance with test parameters:
- Test insulation resistance between capacitor terminals and case. Follow manufacturer's written instructions or those below:
- Use test voltages 500 V minimum, for equipment rated 250 V and less, and 1000 V minimum, for equipment rated more than 250 V. Apply test voltage for 60 seconds.
- Investigate, report, and resolve insulation resistance less than that stated by manufacturer's literature or less than allowable 25 mega ohms for equipment rated 250 V and less and 100 mega ohms for equipment rated more than 250 V.
- Measure capacitance of pole-to-pole capacitor combinations and compare with manufacturer's published values. Report readings, and investigate and resolve discrepancies more than 10 percent of manufacturer's nominal values.
- Energize circuits and demonstrate electrical operating features of automatic power factor correction units according to manufacturer's written instructions.
- Verify accuracy of remotely monitored parameters transmitted from automatic power factor correction units by communication module.

- Correct deficiencies shown by inspections and tests on site where possible, and retest; otherwise, remove and replace with new units and retest.

- Report Tests and Inspections with a written record including adjustments and settings.

# 216 DISTRIBUTION, SUBDISTRIBUTION AND FINAL BRANCH CIRCUIT PANELBOARDS

## 216:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: panelboards for distribution and subdistribution of electric power and for protection of circuits, including fixing and supporting materials and materials for termination of feeders, subcircuits and branch circuits and including necessary interfaces for connection to BMS as specified and/or shown on drawings.

A201 STANDARDS: panelboards generally are to comply with the requirements of:

IEC 61439 Low Voltage Switchgear and Control Gear Assemblies .

IEC 60947-1 Low Voltage Switchgerar and Controlgear, Part 1: General Rules.

IEC 60947-2 Low Voltage Switchgear and Controlgear, Part 2: Circuit Breakers.

IEC 60898 Electrical Accessories – Circuit breakers for overcurrent protection for household and similar installations.

Other components where not specified are to comply with the relevant IEC standards

A251 DESIGNATIONS: panelboards are designated on the Drawings and in the Schedules as follows:

LP:
Final branch circuit panelboards for secondary lighting and power distribution with miniature circuit breaker (MCB) protection on branch circuits, and moulded case switch (MCS) or miniature circuit breaker (MCB) or moulded case circuit breaker (MCCB) on subfeeder, as shown on the Drawings.

DB:
Distribution board for power distribution with MCCB protection on main incoming and outgoing feeder circuit breakers

SMDB:
Sub-Main Distribution board for power distribution with MCS protection on main incoming and MCCB protection on outgoing feeder circuit breakers , form 2b.

MCP:
Motor Control Panel for motors/mechanical equipment power distribution with MCCB protection on main incoming and outgoing feeder circuit breakers

A261 SCHEDULES indicate the designation and required type of panelboard using the following criteria:

- type of construction (MCB or MCCB), referring to type of branch circuit breakers,
- voltage, number of phases and wires,
- branch circuit breaker trip rating and wire size,
- main circuit breaker trip rating and frame size (maximum continuous rating) for MCCB and MCB,
- Short-circuit interrupting capacity (IC) in kA,
- special arrangement or provisions.

A301 EQUIPMENT DATA: submit data for approval including, but not limited to, the following:

- manufacturers' catalogues indicating specific equipment selected,
- types of panelboards and circuit breaker characteristics including duties and ratings compensation at and above 40 deg. C ambient conditions and corresponding temperatures within the enclosures,
- dimensions of panels and specific contents of each panelboard,
- integrated equipment tabulations for coordinated short- circuit series combinations of circuit breakers.

A401 TESTS AND CERTIFICATES: submit complete certified manufacturer's type test and routine test records in accordance with the Standards.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

- exact composition of each panelboard, indicating busbar rating, frame and trip ratings of circuit breakers,
- typical installation details of panelboards, indicating main feeder and branch circuit conduit connections, terminal provisions, tags, labels, mounting methods and materials used.

A551 ELECTRICAL CLOSETS AND ROOMS are to be checked for clearances, spaces and ventilation, for the installation of proposed equipment, prior to starting construction.

A703 COORDINATION STUDY Contractor is to submit a complete coordination and protection study for all the electrical system. The coordination shall be fully detailed to show the short circuit currents at each panel location. The study shall show that the protective devices provided do ensure the proper protection and coordination. Any breakers not satisfying the study shall be replaced by proper ones to ensure proper system operation. The coordination study has to be associated with a coordination study for earth fault currents throughout the system to ensure proper selection of earth fault setting for all breakers to ensure discrimination and proper protection of all system components.

## PRODUCTS AND SYSTEMS

### 216:X SUB-MAIN DISTRIBUTION, DISTRIBUTION AND FINAL BRANCH CIRCUIT PANELBOARDS

### 216:X1 GENERAL REQUIREMENTS

X110 RATED INSULATION VOLTAGE is to be in accordance with the respective Standards.

X115 PANELBOARDS are to be totally enclosed, dead front type, protection code IP 42 for indoor installations and IP 55 for outdoor installations, in accordance with IEC 60947-1 and IEC 60529, and are to be factory designed and assembled.

X125 EARTHING BAR is to be half size the phase busbars.

X128 NEUTRAL BAR is to be sized as the phase bus bars.

X130 PROTECTION is to be fully rated throughout the systems.

X135 SERIES (CASCADE) COORDINATED PROTECTION (integrated equipment short-circuit ratings) will only be acceptable within final branch circuit panelboards, between branch circuit breakers and the main incoming circuit breaker, in accordance with an integrated series combination chart prepared by the manufacturer, tested and certified in the country of origin by an internationally authorized organization, where short-circuit ratings are beyond available fully rated types specified, and with the approval of the Engineer.

X150 CIRCUIT BREAKERS are to be non-fused type.

X155 CIRCUIT BREAKER ARRANGEMENT: panelboards are to have one main incoming circuit breaker or molded case switch (as shown on the drawings) and the required number of branch circuit breakers, all arranged as shown on the Schedules, including spare circuit breakers and spaces for future expansion. Three-phase panelboards are to be designed for sequence phase connection of branch circuit devices.

X160 BRANCH CIRCUIT NUMBERING: on 3-phase panelboard schedules, circuits 1 and 2 are to be connected to Brown (L1) phase, 3 and 4 to Black (L2) phase, 5 and 6 to Grey (L3) phase etc., to conform with branch circuit numbering shown on the Drawings.

## 216:X2 PANELBOARD ENCLOSURES

X210 TYPE: general purpose type, suitable for relevant ambient conditions, flush or surface mounted as shown on the Drawings, comprising box, trim, or trim and door to approved manufacturer's standards and sizes.

X220 CONSTRUCTION: box, trim and doors where required, are to be electro-galvanized sheet steel of gauges not less than specified and in accordance with the Standards. Welded joints are to be galvanized after manufacture. Gutter spaces are to conform to the Standards, adequate for the utilized cables/wires subject to the Engineers' approval and in no case less than 100 mm on all sides. Enclosure is to have predesigned angles or threaded end studs to support and adjust mounting of interior panelboard assembly.

X230 TRIMS are to cover and overlap front shield, covering all terminals and bus compartments, to form a dead front panel. Trims are to be fixed to cabinet/box by quarter-turn clamps engaging flange of box (use of screws engaging holes in flange of box is not acceptable). Screws where used are to be oval-head, countersunk and flush. Trims for flush mounted panelboards are to overlap box and front shields by at least 20 mm. Trims for surface mounted panelboards are to be exactly sized to form flush fit to box.

X240 DOORS are to have concealed hinges integral with trim, and flush combination cylinder lock and catch. Doors over 1000 mm high are to have vault-type handle and multiple point latch mechanism. Locks are to be keyed alike.

X250 FINISH: inner and outer surfaces of cabinet/boxes, trims, doors etc. are to be cleaned, phosphatized, chrome passivated and treated with final thermosetting epoxy powder modified by polyester resins providing high resistance to mechanical injury, heat, acid and alkali solvents, grease, aging and corrosion and of standard grey colour to the approval of the Engineer.

X260 DIRECTORIES under glassene, or an approved alternative durable arrangement, are to be provided on inside face of doors, or in metal label holders when trim without doors is specified. Directories are to be typed to identify panelboards and clearly indicate circuit number and description of load.

X270 OUTDOOR ENCLOSURES are to be heavy duty sheet steel cabinets, minimum 1.5 mm thick, fully weatherproofed (IP 55), without knockouts, but with removable sealed/gasketed bottom gland plates and gasketed doors.

216:X3 BUSBARS

X310 TYPE: one piece, 98% pure electrolytic copper, based on total maximum operating temperature of 90 deg. C at any point of the bus, at full continuous rating. Bolted or clamped contact surfaces are to have maximum current density not exceeding requirements of the approved standards. Aluminium is not to be used for busbars or panelboard parts.

X320 DESIGN: busbars are to be shrouded/insulated and rigidly designed so that branch circuit devices can be removed without disturbing adjacent units or changed without additional machining, drilling or tapping. Busing is to be full size without reduction. Busing and blank plates are to allow installation of future circuit devices, where indicated on the Drawings.

X325 RATING: busbar rating is to be at least equal to main-circuit breaker frame size. Where no main circuit breaker is required, busbars are to have main lugs or disconnect switch, with nominal rating equal to 1.25 times the up stream circuit breaker trip ratings, and as shown on the Drawings.

X330 SHORT-CIRCUIT DUTY: busbars are to carry at least 125% of the maximum short-circuit level at point of application for one second, without showing any signs of degradation.

X340 TERMINALS AND CONNECTIONS are to be anti-turn, solderless screw-pressure type. Screws and bolts used for making copper/copper connections are to be hard copper alloy with lock washers (riveted bus connections are not acceptable).

X350 NEUTRAL BAR is to be solid and fully insulated from cabinet or box. One solderless box type set-screw connector is to be provided for neutral wire of each branch circuit and one bolted clamp-type connector or anti-turn lug with set-screw for main incoming neutral wire. Neutral is to be fully sized and rated as for phase busbars.

X360 EARTHING BAR is to be copper, brazed to panelboard cabinet, with bolted pressure connector for main conductor and one set-screw-type tunnel terminal for each outgoing conductor, to provide secure and reliable contact with all metal parts and enclosure.

## 216:X4 MOULDED CASE CIRCUIT BREAKERS (MCCBs)

X410 TYPE: tested to approved standards, minimum rated insulation voltage of 500 V for 100 A frame size and 690 V for frame sizes higher than 100 A, totally enclosed, bolt-on moulded case type, constructed from high quality, high temperature resistant, tropicalized, moulded insulating materials, for normal operation at maximum temperature within enclosures at point of application, and provided with front operated single toggle type handle mechanism for manual operation of main contacts in addition to automatic operation under overcurrent conditions. Multi-pole breakers are to have common integral trip bar for simultaneous operation of all poles. Ampere rating is to be clearly visible. All terminals are to be box lug or clamp type with set screws, suitable for copper or aluminium conductors.

X416 CIRCUIT BREAKER TRIP UNITS: unless otherwise specified or indicated on the drawings, moulded case circuit breakers of final branch circuit panel boards (LPs), power panel boards (PPs ) and subdistribution panel boards (SDPs) are to be thermal magnetic type, while moulded case ciruit breakers of distribution panel boards (DPs) are to be thermal-magnetic for frame sizes up to 160 A and electronic type for higher frames.

X420 THERMAL MAGNETIC CIRCUIT BREAKER TRIP UNITS: are to have bi-metallic inverse time delay overcurrent element for small overloads and instantaneous magnetic overcurrent trip element for operation under short-circuit conditions on each pole. Circuit breakers frame sizes are to have adjustable instantaneous trips.

X425 COMPENSATION: thermal overcurrent trips are to be ambient temperature conpensated between 25 and 50 deg. C.

X427 ELECTRONIC TRIPS UNITS: applicable to circuit breakers 160 A frame size and larger, are to be solid state with long time delay settings between 0.5 and 1.0 times maximum trip rating, short time delay range of 3 to 10 times maximum trip rating with a maximum clearing time 0.2 seconds, and instataneous protection adjustable from 5 to 10 times continuous rating. Solid state trip units are to be insensitive to changes in ambient temperature between –20 and +55 deg. C. Earth fault protection is to be built into trip unit where specified, and is to be suitable for connection to external current sensor. Push-to-trip button is to be provided on cover for testing the trip unit.

X430 SWITCHING MECHANISM: quick-make, quick-break type, with positive trip-free operation so that contacts cannot be held closed against excess currents under manual

or automatic operation. Contacts are to be non-welding silver alloy with approved arc-quenching devices of metallic grid construction.

X435 TRIP CURRENT RATING (AMPS) indicates nominal maximum rating at which overload element is set to operate.

X440 MCCBs FOR LPs and DBs & SMDBs Type 2: to comply with IEC60947-2 test sequences I, II, utilization category A, and are to have rated ultimate short circuit breaking capacities (Sequence III) to meet the electrical requirements at the panelboard location, with preferred ratings in accordance with following tables.

X445 MCCBs FOR SMDB: are to be rated for maximum operating voltage of 600V a.c., 250 V d.c. and utilization category B (with an intended short time withstand capability), and are to have rated service short circuit breaking capacities (Sequence II) with suitably selected frame sizes and trip ranges to meet the electrical requirements at the distribution panelboard location and schedules shown on the drawings, with declared ratings as percentage (100%) of the ultimate ratings as quoted by the circuit breaker manufacturer and marked on the circuit breaker rating plate.

X450 FRAME SIZE is defined as maximum continuous current rating of circuit breaker which corresponds with its maximum trip range listed below and which is to be related to minimum acceptable short-circuit interrupting ratings, based on fully rated interrupting duties: normal duty (N), high break (H), or current limiting (L), as specified.

X451 FRAME SIZES are generally to be selected with minimum interrupting capacities at specified voltages and rated frequency, in accordance with the following table:

| Trip range frame size(amperes) | Minimum Symm. rms rated breaking capacity(ultimate in kA) | | | Rating volts(a.c.) |
|---|---|---|---|---|
| | N | H | L | |
| Thermal-magnetic | | | | |
| 15-100 (1p) | 25 | - | - | 220/240 |
| 15-100 (2,3p) | 25 | - | - | 380/415 |
| 15-160 (2,3,4p) | 35 | 60 | 100 | 380/415 |
| Electronic | | | | |
| 100-250 (2,3,4p) | 35 | 60 | 150 | 380/415 |
| 160-400 (2,3,4p) | 35 | 60 | 150 | 380/415 |
| 300-600(2,3,4P) | 40 | 60 | 150 | |
| 400-800 (3,4p) | 50 | 60 | 150 | 380/415 |
| 800-1250 (3,4p) | 50 | 70 | 150 | 380/415 |

X460 TRIPPED POSITION: when tripped automatically by overcurrent condition, operating mechanism of circuit breaker is to assume an intermediate position clearly indicated by the handle between on and off positions.

X465 INTERCHANGEABLE TRIPS: electronic or thermal-magnetic trip circuit breakers of 150/160 A frame size and up to 630 A frame size are to have interchangeable trip units.

X466 SEALING: circuit breakers with non-interchangeable trip units are to be sealed. Circuit breakers with interchangeable trip units are to have trip unit covers sealed to prevent tampering.

X470 ACCESSORIES: circuit breakers are to be designed to accommodate standard attachments including shunt-trip, under-voltage release, combined auxiliary and alarm switches, and electrical operator to any circuit breaker of rating (frame size) 100 A and over. Padlocking devices are to be provided, where shown on the Drawings.

X480 RESIDUAL CURRENT OPERATED EARTH LEAKAGE TRIP DEVICES (RCDs) are provided as add-on or built-in earth leakage accessories, where required and as shown on the Drawings. Protection against earth fault current, in addition to overcurrent and short-circuit protection, is to be in accordance with the Regulations. Trip current sensitivity on breakers for branch circuits is to be 5/10/30/300 mA (as shown on the darwings), and for main breakers ratings are to be as shown on the Drawings. Circuit breakers are to include current transformer with tripping coil assembly, test button and trip free mechanism to ensure circuit breaker cannot be held closed against earth faults.

X490 CURRENT LIMITING CIRCUIT BREAKERS: moulded case type without fusible elements. When operating within current limiting range, the I2t of let-through current is to be less than 1/2 cycle wave of symmetrical protective short-circuit current as compatible with breaker construction.

X491 CURRENT LIMITING CIRCUIT BREAKERS are to have, on each pole, adjustable inverse time-delay over-current characteristics for overload protection and instantaneous trip for short-circuit protection. Operation of main contacts is to be based on electro-magnetic repulsion forces between contacts created by fault current. Ratings are specified at rated voltage for an rms value of prospective short-circuit current.

216:X5 MINIATURE CIRCUIT BREAKERS (MCBs)

X510 TYPE: thermal magnetic non-adjustable type, tested in accordance with IEC 60898, (250/440V) rated insulation voltage.

X520 MINIMUM SHORT-CIRCUIT BREAKING CAPACITIES are to be as follows:

6 - 100 A MCB : 10, 16, 20 or 25 kA at 220/380 V a.c.

X525 CONSTRUCTION: MCBs are to be tropicalized for operation at ambient temperatures up to 70 deg. C within panelboard enclosure and humidities up to 95%, and are to be constructed from high quality, high temperature, moulded insulating materials. Guaranteed duties and characteristics are to be submitted for temperatures above 40 deg. C.

X527 MCBs and combination devices are to be modular, of unified profile and suitable for mounting either to a standard DIN rail, or a plug-in system.

X530 OPERATION: under overload conditions, thermal tripping is to provide close protection of insulated conductors. Under short-circuit conditions, magnetic trip is to operate at 7 - 10 times normal rated current (type 3 characteristic). Magnetic operation is to be in the current limiting region and opening time is not to exceed 5 milli-seconds.

X540 RATINGS: preferred rated currents are to be 6, 10, 16, 20, 25, 32, 40, 50, 63, 80 and 100 A, calibrated at 40deg.C, available as 1, 2, 3 and 4-pole circuit breakers. Derating above 40 deg. C is not to exceed 1% per deg.C, and loading is not to exceed 70% of circuit breaker rating.

X550 RESIDUAL CURRENT DEVICES for earth leakage protective circuit breakers are to be add-on devices, or built-in and integral with the standard circuit breaker. Non-

adjustable sensitivities of 10 mA, 30 mA, 100 mA and 300 mA are to be available for all ratings of 2-pole and 4-pole circuit breakers.

X570 AUXILIARIES where shown on the Drawings, are to include alarm switch, auxiliary switch, shunt trip, under voltage trip and similar units which are to be modular additions to the circuit breakers.

## 216:X6 MOULDED CASE SWITCH (MCS)

X601 MOULDED CASE SWITCH: non-automatic on/off switching device of equal construction to equivalent circuit breaker, having no overcurrent or fault protective elements, but marked with maximum current withstand and voltage rating.

## 216:Z PANELBOARD ASSEMBLIES

### 216:Z1 SUB-MAIN DISTRIBUTION BOARDS (SMDB)

Z110 SMDB: shall have a rated insulation voltage of 690 V a.c., 240 V d.c., surface mounted to wall or free standing , with doors (unless otherwise shown on the Drawings), suitable for ratings of main breaker and busbars, 3-phase, 4-wire suitably and orderly arranged for indicated combination of branch MCCBs frame size and short-circuit interrupting ratings as shown on the Drawings.

Z130 CONSTRUCTION: sheet steel, minimum 1.5 mm thick for cabinet/box and minimum 2 mm thick for trim or trim and door. Fronts are to be single or twin covers to shield circuit breakers, terminals and live ends.

Z135 INTERIOR OF PANELBOARD is to be pan assembly consisting of galvanized sheet steel chassis minimum 2 mm thick, folded, flanged and reinforced, with busbars vertically arranged and mounted on moulded insulators.

Z140 MOULDED INSULATORS are to have minimum temperature rating of 130 deg. C and insulation grade of 3.5 kV for one minute.

Z150 CIRCUIT BREAKERS are to be mounted in twin arrangement (except for larger circuit breakers) and bolted rigidly to copper cross and center bus connectors.

## 216:Z2 FINAL BRANCH CIRCUIT - GENERALLY

Z210 ARRANGEMENT: to comprise set of homogeneous branch circuit breakers with unified profile and base, and one main circuit breaker or switch as shown on the drawings. Single and multi-pole circuit breakers or other devices are to occupy modular spaces. Accommodation of contactors and split-bus arrangement or other devices is not to change regularity of standard box width.

Z220 INDOOR ENCLOSURE: sheet steel, minimum 1.0 mm thick for box/cabinet and minimum 1.5 mm thick for front shield, trim and door. Fixings for flush trim are to be adjustable to allow for mis-alignment between box and wall surface. Wiring spaces (gutters) are to be at least 100 mm wide. Larger gutters are to be provided where tap-off insulated split connectors are required. Knockouts are to be provided in top or bottom of enclosures and are to provide a neat and uniform conduit/cable terminal arrangement.

## 216:Z3 DISTRIBUTION BOARDS - TYPE MCCB

Z310 TYPE: : to have a rated insulation voltage rating 690 V, 3-phase and neutral (TPN), with bolted 3-pole MCCBs on branch circuits and 3 pole MCCB on main incoming (or MCS on main incoming as shown on the drawings), listed by Under Writer's Laboratories Inc., File No. E2269 or equal, and meeting Federal Specification W-P-115b Type 1 Class 1.

Z320 BRANCH CIRCUIT BREAKERS are to be 3-pole, rated 100 A frame size, with trip ratings between 15 A and 100 A, and compatible ICs, selected from normal (N), high-break (H) or current-limiting (L) range.

Z330 MAIN CIRCUIT BREAKER is to be 3-pole continuous rating , with trip ratings and fully rated non-current limiting ICs of normal (N) or high-break (H) ranges, with or without residual current device (RCD) as indicated on the Drawings.

Z340 SHORT-CIRCUIT RATING: panelboards may only have integrated equipment (series) short-circuit rating in accordance with clause 216:X135 hereof.

Z350 ASSEMBLY: busbars are to be rigidly fixed on moulded insulators to back pan in vertical arrangement. Branch circuit breakers are to be bolted in twin arrangement to rigid copper cross and center bus connectors. Back pan assembly is to be removable and fixed to four threaded studs integral with cabinet.

## 216:Z4 FINAL BRANCH PANELBOARDS - TYPE MCB

Z405 TYPE: to have a rated insulation voltage rating 690 V.

Z412 INTERNAL ASSEMBLY: to comprise removable back plate or back pan of rigid construction, attached to enclosure by four captive screws through keyhole fixings, and provided with busbars in horizontal arrangement for SPN panels and in vertical arrangement for TPN panels. Assembly is to be complete with neutral terminal block, earthing bar and one-piece insulated phase busbar. Busbars are to be single-phase or 3-phase with spade connectors for fixing by tightening a single screw on circuit breaker. Insulation is to be high thermal rating, capable of carrying maximum short-circuit current for one second without overheating beyond acceptable limits required by the Standards.

Z420 SPN TYPE PANELBOARDS are to be suitable for 240 V maximum service voltage, single-phase and neutral, with MCBs on branch circuits and main incoming (or MCS on main incoming as shown on the darwings).

Z430 SPN TYPE MAIN CIRCUIT BREAKER is to be double-pole MCB, with or without earth leakage device (RCD), as shown on the Schedules.

Z440 SINGLE-POLE AND DOUBLE-POLE MCBs for 240 V service, are to have trip ratings between 6 A and 50 A, with ICs as required in the Schedules.

Z450 TPN TYPE PANELBOARDS are to be suitable for up to 415 V a.c. maximum service voltage, 3-phase and neutral, with MCBs on branch circuits and 3 or 4-pole MCS or MCCB main incoming, as shown in the Schedules or on the Drawings.

Z460 TRIPLE-POLE BRANCH CIRCUIT BREAKERS are to have trip ratings between 6 A and 100 A, with IC as required in the Schedules.

Z470 TPN TYPE PANELBOARD MAIN CIRCUIT BREAKERS are to be MCCB, 100A , normal (N) or high-break (H) duty with/without RCD as shown on the Drawings.

Z480 SHORT-CIRCUIT RATING: TPN panelboards may only have an integrated equipment (series) short-circuit rating in accordance with clause 216:X135 hereof.

## 216:Z5 MOTOR CONTROL PANELS

Z510 LOW VOLTAGE MOTOR CONTROL PANELS shall have the following characteristics, as a minimum:

• Totally enclosed type, free-standing sectionalized type, modular, compartmented
• IP 43 for indoor installation and IP 65 for outdoor installation and in wet areas (e.g. pump rooms)
• Form 3b to IEC 61439-1 with separate withdrawable section for each motor starter and separate fixed section for main incoming breaker / switch and each outgoing feeder circuit breaker
• 2-mm thick sheet steel; adequately reinforced and braced for maximum rigidity, sand blasted, rust inhibited after fabrication and sprayed with one coat primer and two coats enamel internally and externally

Z520 MOTOR CONTROL PANEL to include the following:

- Main incoming circuit breaker or isolating switch
- Main copper horizontal full-length busbars rated as main incoming circuit breaker
- Branch copper vertical full height busbars of adequate capacity to distribute power to each circuit breaker and starter served
- Neutral copper busbar rated at half capacity of main busbar and distributed throughout whole motor control center
- Earth copper busbars minimum 25 x 6 mm extending full length of motor control center
- Busbars to be adequately isolated and braced to sustain maximum possible short circuit current
- One voltmeter with commutator, range 0-415 V
- Ammeters (3 Nos.) on main supply with necessary current transformers
- Starters, circuit breakers, push buttons, indicating lights, switches, relays, contactors and accessories, as deemed necessary
- Interconnecting and interlock wiring
- Compartment doors to be interlocked so that isolators or breakers must be in OFF position before door can be opened

FIELD AND INSTALLATION WORK

216:1 INSTALLATION

1101 FIXING GENERALLY:

- align, level and securely fasten panelboards to structure,
- fix surface mounted outdoor panelboards at least 25mm from wall ensuring supporting members do not prevent flow of air,
- do not use connecting conduits to support panelboards,
- close unused openings in panelboard cabinets.

1201 PANELBOARD INTERIORS: do not install in cabinets until all conduit connections to cabinet have been completed.

1301 WIRING INSIDE PANELBOARDS: to be neatly arranged, accessible and strapped to prevent tension on circuit breaker terminals. Tap-off connections are to be split and bolted type, fully insulated.

1401 TRIM: fix plumb and square prior to painting. Fix trim for flush mounted cabinets flush with wall surface finish.

1501 PROTECTION: treat concealed surfaces of recessed cabinets with heavy field application of waterproof compound prior to installation.

216:2 INSPECTION AND TESTS ON SITE

2101 GENERALLY: carry out all tests, required by the coverning codes and by the Engineer, on panelboards after installation, to verify compliance with the specifications and standards. Inspect conditions within panelboards and verify insulation conditions by use of a megger.

2201 CIRCUIT BREAKERS: tests are to include operation of every circuit breaker manually. Check automatic operation of selected circuit breakers, as required by the Engineer, by applying necessary short-circuit, overload and earth leakage current for tripping circuit breaker as applicable and compare with manufacturer's data/characteristic curves. Measure and report ambient temperature inside enclosure.

2301 INSULATION CHECK TESTS: carry out insulation tests on all busbars, between phases and between phases and earth/cabinet, and between neutral and earth. Record all readings, using 500 V megger for equipment on 240 V systems, and 1000 V megger for equipment on systems up to 600 V, for 1-minute, with circuit breakers in open position.

2305 ROUTINE TESTS ON SITE are to be carried out, in accordance with the Standards, on all panelboards assembled from standardized components of the manufacturer outside the works of the manufacturer.

2401 FIELD TEST REPORTS: submit written test reports and include the following:

- Test procedures used,
- Test results that comply with requirements,
- Results of failed tests and corrective action taken to achieve test results that comply with requirements.

# 217 WIRES, CABLES, FEEDERS AND RELATED ACCESSORIES

## 217:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: low voltage (LV) feeder cables, busbar trunking, branch circuit wiring, control and signal cables and medium voltage (MV) feeder cables, termination, jointing and splicing.

A161 CURRENT CARRYING CAPACITIES OF CONDUCTORS have been determined in accordance with the Regulations for specified type of insulation and expected conditions of installation. No change will be accepted in specified type of insulation unless warranted by special conditions and approved by the Engineer. Check various loads and current carrying capacities and report any discrepancies or insufficiency of sizes indicated to the Engineer.

A201 STANDARDS: wires and cables are to comply with IEC or other equally approved standards and are to bear the mark of identification of the Standards to which they are manufactured. Wires and cables not having this identification will be rejected.

A301 TECHNICAL DATA: submit data for approval including, but not limited to, the following:

constructional details, standards to which cables comply, current carrying capacities, derating factors for grouping and temperature,

manufacturer's catalogue cuts,

dimensional and electrical characteristics,

samples of each cable and wire and, if requested by the Engineer, other accessories.

A351 DELIVER wires and cables properly packaged in factory packed or fabricated containers, wound on factory reels. Store wires and cables in dry areas, and protect from weather, fumes, water, debris, etc.

A401 CERTIFICATE OF ORIGIN: for each lot of cable supplied, provide a certificate of origin issued by manufacturer stating origin, date of manufacture, composition, standards to which it complies and test certificates. All test certificates are to comply with the test requirements of the relevant standard to which the cable is manufactured.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

exact routing layouts, sections and profiles of busducts, trays, feeder, sub-feeder cables and branch circuits, with indication of any equipment to show and verify coordination between various trades

details of supports and fixings for buses, trays and cables

details of connections to transformers, switchboards, panelboards etc.

details of terminations, splices and tappings where permitted, glands and bushings at enclosures

number and size of conductors in conduit for all branch circuits in accordance with final conduit routing.

## PRODUCTS AND SYSTEMS

### 217:X CABLES, WIRES, FEEDERS AND ACCESSORIES

### 217:X1 GENERALLY

X120 CONDUCTORS: unless otherwise specified or shown on the Drawings, cables and other feeders are to have copper conductors. Cable conductors are to be stranded for sections 4 mm2 and above, based on IEC 60228 Class 2. Signal and control cables are to have solid conductors unless otherwise specified. Flexible cords are to have finely stranded conductors. Conductors of single core cables 25 mm2 and above are to be compacted. Multi-core cables 35 mm2 and above are to be sectoral shape.

X125 CONDUCTOR SIZES are to be metric and as shown on the Drawings. Conductors with cross-sectional area smaller than specified will not be accepted.

X130 BUILDING WIRING INSULATION is to be color coded or otherwise identified as required by the Regulations and as follows:

neutral is to be blue

protective earth is to be green or green/yellow striped

phase colours where not specified by the Regulations are suggested as brown, black, grey for 380/220 V systems.

Or use colour coding in accordance with local regulations and standards.

Maintain colour coding throughout installation. Phase-conductors for which outer jacket is not colour coded are to have engraved alphanumeric mark (L1, L2, L3) or colour coded heat-shrinkable sleeves.

X150 BURIED CABLES: cables buried directly in the ground are to be armoured type, unless otherwise indicated in particular Sections of the Specification or on the Drawings.

## 217:X2 LV WIRES AND CABLES

X212 SINGLE CORE PVC INSULATED CABLES (BUILDING WIRES): unless otherwise specified, single conductor cables for wiring in conduit are to have annealed copper conductors, compacted, generally with concentric strands and insulated with flame retardant, moisture and heat resistant PVC to IEC 227 (or to BS 6746), suitable for wet locations and for conductor temperature of 70 deg. C. Wires and cables are to be 450/750 V grade.

X214 MULTI-CORE PVC INSULATED CABLES (0.6/1 kV): to have annealed, copper conductors, compacted, insulated with PVC to IEC 60227 (or to BS 6746), flame retardant, moisture and heat resistant, suitable for wet locations and conductor temperatures of 70 deg. C, laid up, bedded with suitable filler and sheathed with PVC. Armoured cables are to have single layer of galvanized steel wire armour with PVC oversheath. Cables are to comply with IEC 60502 and IEC 60811 and IEC 60885.

X215 SINGLE CORE XLPE INSULATED FEEDER CABLES (0.6/1 kV): single-core circular stranded, annealed copper conductors, compacted, insulated with flame retardant, moisture and heat resistant cross-linked polyethylene (XLPE), suitable for wet locations and conductor temperatures of 90 deg. C. and PVC over-sheath. Armoured cables are to have taped bedding, single wire aluminum armour and PVC over-sheath.

X220 MULTI-CORE XLPE INSULATED FEEDER CABLES (0.6/1 kV): single core annealed copper conductors, compacted, XLPE insulated, for conductor temperature of 90 deg. C, laid up and bedded with suitable non-hygroscopic material compatible with the insulation and PVC oversheathed, colour black. Armoured cables are to have single layer of galvanized steel wire applied helically over extruded PVC bedding (which may be an integral part of filling) and oversheathed with PVC, colour black. PVC oversheaths are to be type ST2 to IEC 60502.

## 217:X3 24 kV MV CABLE

X315 THREE CORE MV CABLE (24 kV maximum between phases), XLPE insulated, is to comply with IEC 60502, and have the following characteristics:

| | | |
|---|---|---|
| conductor | : | copper, circular, stranded and compacted |
| conductor screen | : | extruded semi-conducting layer |
| insulation | : | extruded cross-linked polyethylene (XLPE) |
| insulation screen part | : | non-metallic directly applied extruded semi-conducting material, readily strippable |
| metallic part | : | layer of copper tape applied with 30% overlap |
| filling and bedding | : | polypropelene extruded over laid up cores to form compact circular bedding |
| armour | : | single layer of round galvanized steel wire |
| outer sheath | : | extruded PVC (color red) type ST2 to IEC 60502 |
| embossing | : | electric cable 20000 V |

X325 CABLE JOINTS to be as recommended by manufacturer, to render joints equal to cable in characteristics, in terms of insulation, stress distribution and water-tightness. Materials and methods of jointing are to be approved before confirmation of order.

## 217:X4 CONTROL AND SIGNAL CABLES

X410 MULTI-CORE PVC INSULATED CONTROL CABLES: 0.6/1 kV rating, solid 1.5 mm2, 2.5 mm2 or stranded 4 mm2 plain circular copper conductors, with heat resistive PVC/E to IEC 60227 (PVC type 5 to BS 6746), rated for 85 deg. C, of 7, 12, 19, 24, 30 or 37 cores. Cores are to be laid up together and filled with non-hygroscopic material, PVC oversheathed, to form compact and circular cable for use in switchgear, control gear and generally for control of power and lighting systems. Armoured cable is to have extruded PVC bedding which may be an integral part of the filling, galvanized steel wire armouring, and oversheath of PVC type ST2 to IEC 60502, colour black. Core identification is to be white printed numbers 1, 2, 3 etc. over black insulation.

X450 PE INSULATED CONTROL AND SIGNAL CABLES, for use on data systems, are to be generally 300 V rating, polyethylene insulated, colour coded, tinned copper conductors (0.6 mm diameter), twisted together into pairs. Multi-pair core assembly is to be covered with binder tape, spirally wound 0.075 mm bare copper shielding tape and provided with drain wire and overall PVC sheath.

X455 CONTROL AND SIGNAL CABLES, enclosed in conduit and raceways with power cables, are to be insulated for same voltage grade.

## 217: X5 CONNECTORS (LV POWER)

X510 CONNECTOR - TYPE A-1: pressure indent type, for terminating or making T-taps and splices on conductors 10 mm2 and smaller. Connector is to be non-ferrous copper alloy applied to conductor by mechanical crimping pressure, with vinyl insulating sleeves or phenolic insulating covers.

X520 CONNECTOR - TYPE A-2: bolted pressure split type for terminating or making T-taps and splices on conductors 16 mm2 and larger. Connector is to be cast non-ferrous copper alloy applied to conductor by clamping with minimum of two screws and provided with phenolic insulating cover.

X530 CONNECTOR - TYPE B-1: pre-insulated, spring type, for branch circuit and fixture wiring. Connector is to be steel encased spring with shell, insulated with vinyl cap and skirt, type Scotchlok brand, as manufactured by Minnesota Mining & Mfg. Co. or other equal and approved.

FIELD AND INSTALLATION WORK

217:1 WIRING AND CABLING INSTALLATIONS

1101 GENERAL: building wires and cables are to be installed in conduit, trunking or ducts indoors and in conduit outdoors, unless otherwise shown the Drawings.

1201 CIRCUITS: unless otherwise shown on the Drawings, final branch circuit wiring is to be run inside trunking or conduits, D.C. wiring is to be run in separate conduits from a.c. wiring, and emergency lighting and power circuits are to be run in separate conduits from normal circuits.

1301 BRANCH CIRCUIT WORK originating from light and power panelboards is to be arranged as shown on the Drawings. Loads on various phases of panelboards are to be balanced. Contractor is toe ensure that the lighting load and other loads are balanced with a difference of not more than 10% between the phases.

1451 CONTROL CABLES may be fixed to racks, installed directly on cable trays or pulled in conduit and trunking indoors, and in underground ducts or in conduit outdoors.

1501 BUNCHING OF WIRES IN RACEWAYS is to be in accordance with raceway filling factors permitted by the Regulations.

1511 BEFORE PULLING WIRES IN CONDUITS check that inside of conduit (and raceway in general) is free of burrs and is dry and clean.

1521 LUBRICANTS are to be used for pulling wire or cable if character of pull would otherwise damage conductors, insulation or jacket. Lubricants are to be approved by the Engineer.

1525 PULL CONDUCTORS INTO RACEWAYS simultaneously where more than one is being installed in the same raceway.

1531 SUPPORT: cables and wires pulled inside very high conduit risers are to be supported at upper end of risers and at intermediate points by split rubber grommets to relieve any stresses on conductors, where required.

1551 WIRING AT OUTLETS: leave a slack of at least 200mm at each outlet.

1601 EXTRA LENGTH: at every branch circuit outlet and pull-box, every cable passing through is to be left slack to allow inspection and for connections to be made. Cables terminating in outlet boxes are to be left with at least 250 mm extra length for terminations.

1651 JOINTS OR TAPS in wires and cables, if permitted, are to be permanently accessible or made only in boxes or cabinet gutters.

1661 CONNECTORS for terminating or making T-taps and splices are to be Type A-1 on conductors 10 mm2 or smaller, Type A-2 for conductors 16 mm2 and larger, and Type B-1 for branch circuit and fixture wiring.

1701 INSULATING COVERS are to be applied to prevent exposure of bare cable connections.

1751 SWITCH LEGS for local wall switches are to have distinctive colour, selected as complementary to cable colour coding used in the project.

1771 TERMINATIONS: conductors of wires and cables up to 16mm2 are to be tightly twisted and where possible doubled back before being clamped with set screws. Where two or more wires are looped into same terminal these conductors are to be tightly twisted together before inserting into terminals. In no case is bare conductor to be allowed to project beyond any insulated shrouding or mounting of a line terminal. Cables sizes 16 mm2 and larger are to terminate in tunnel lugs with set-screw, or by using bolted or sweated compression connectors.

1801 TAGGING: tag main and feeder cables in pull-boxes, wireways and wiring gutters of panelboards or distribution cabinets. Tags are to identify cable or circuit number and conductor size in accordance with the Schedules.

1802 TAGGING: where two or more circuits are run to or through a control device, outlet box or ceiling junction box, each circuit is to be tagged as a guide in making connections.

1805 TIGHTEN electrical connectors and terminals including screws and bolts, in accordance with manufacturers published torque-tightening values. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with international standards.

217:2 FEEDER AND SUB-FEEDER INSTALLATION (0.6/1 kV)

2101 CABLES GENERALLY are to be run through duct-banks, shafts or special recesses, clamped to steel racks or cable trays. Cables run through ventilation shafts are to be installed in steel conduits.

2151 FIXING: single cables above suspended ceilings or in concealed spaces are to be fixed directly to walls or ceilings but must be accessible. Where two or more cables are run in parallel, they are to be fixed on galvanized steel perforated trays or on other approved special cable supporting and protecting arrangement.

2201 CLAMPS: where cables are fixed to steel trays or supporting structures, approved galvanized cast steel clamps (or moulded plastic clamps for single core cables) are to be used at distances not exceeding 20 diameters.

2251 JOINTS OR SPLICES will not be accepted on main and sub-feeders. Cables are to be supplied in lengths sufficient for straight-through unjointed termination to termination pull.

2301 DIRECTLY BURIED CABLES crossing under roads, pipe banks or other services, are to be laid in heavy duty PVC duct banks. In no case are cables to be directly buried in concrete, in masonry or in floor finishings.

2351 BURIED CABLES LIABLE TO MECHANICAL DAMAGE are to be drawn through PVC conduit or asbestos cement pipe. If steel conduit is used, all three phase conductors, neutral and protective earth circuits are to be in the same conduit.

2401 EXPOSURE TO HEAT: route wires and cables to prevent exposure to excessive heat or to corrosive agents. If such condition is unavoidable, cables are to be type designed for particular condition.

2501 INSULATING COVERS are to be applied to prevent exposure of bare cable connections. Insulating cover is to be purpose made and is to provide minimum insulation level equal to that of conductor insulation.

2551 GLANDS for various single-core and multicore cables are to be purpose made and suitable for rigid mounting to equipment enclosure.

## 217:3 FEEDER CABLE JOINTING AND TERMINATING

3051 THROUGH JOINTS will not be allowed in feeder cables where adequate manufacturer's lengths are available. Where a joint is necessary, it has to be made inside boxes, handholes or manholes.

3101 RECOMMENDATIONS: through joints and terminations are to be carried out strictly in accordance with cable manufacturer's recommendations, and made with correct specified materials, boxes, tapes, compounds or mixtures, stress cones, glands and bonds as applicable.

3151 JOINTING: skilled operatives are to be employed for jointing of cables. Qualifications of operatives are to be submitted to the Engineer prior to work commencing on site. Joints are to be filled with epoxy resin after taping unless contrary to cable manufacturer's recommendations. Sample site constructed cable terminations and through-joints are to be submitted to the Engineer prior to commencing work on site. Samples are to be constructed in the presence of the Engineer and are to be available to the Engineer for test and inspection in accordance with manufacturer's recommendations.

3201 CUTTING TOOLS for jointing and terminating cables are to be purpose made, to prevent damage to insulation in general, and to cable shielding of MV cables.

3251 CLEANING OF LACQUER ON CONDUCTORS is to be by use of 'Scotch Brite' sponge and white spirit or equal approved.

## 217:4 TESTING

4101 CABLE TESTS are to be carried out in accordance with the requirements of the Regulations and Standards.

4201 TEST EQUIPMENT: provide megger testers of various ranges as applicable, and HV test equipment as necessary for testing MV installations. Use 500 V megger on installations with nominal voltage up to 500 V, 1000 V megger on installations with nominal voltage over 500 V up to 1000 V, and 5000 V megger on MV installations (up to 13.8 kV) for initial checks.

4301 INSULATION RESISTANCE for LV power and lighting installations is to be carried out in accordance with IEE Regulations 613-5 through 613-8 and 713-04.

4302 INSULATION RESISTANCE for control and signal cables is to be minimum 10000 Megohm-km for PE insulated cables and 100 Megohm-km for PVC insulated cables, all measured core-core and core-earth, in accordance with the Regulations.

4401 MV CABLE TESTING: provide cable test set with d.c. output voltage and ampere range sufficient to test MV cables. Cables are to be laid in position (trench or duct bank), jointed where applicable, but left uncovered, with ends free of equipment and clear of ground.

4402 MV CABLE TESTING: d.c. test voltage is to be applied between core under test and the screen in steps, pausing one minute or more each step (first step being the a.c. rms rated voltage of the cable, followed by two equal steps) up to maximum test voltage. At each step, and for the last 5-15 minutes duration at maximum test voltage, the ammeter (normally a micro-ammeter) is to be closely and recorded. If, except as voltage is increased, the current starts to increase, test is to be stopped and the installation inspected and tested for the fault.

4403 MV CABLE TESTING: each cable/core is to be tested independently. Maximum d.c. test voltage for grounded neutral system is to be 3 times rated a.c. rms voltage of cable.

4404 MV CABLE TESTING: alternative test is to apply a.c. rms voltage up to 1.5 times a.c. rms rating of cable, applied for 15 minutes, by an approved a.c. test set. Readings are to be within same range and in accordance with IEC 60502.

# 218 CONDUITS, WIREWAYS, SUPPORTING SYSTEMS AND RELATED ACCESSORIES

## 218:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: raceways including conduits, wireways, cable trays, and related installations and accessories necessary to support and protect cables, feeders, sub-feeders, branch circuit wiring and wiring of low current systems, communications and signal cables.

A201 REGULATIONS AND STANDARDS: conduits, wireways, cable trays and fittings are to be designed, constructed and installed to give safe installation and reliable mechanical protection for wires and cables in accordance with the Regulations. Standards of products are to be as specified.

A301 TECHNICAL DATA: submit data for approval including, but not limited to, the following:

Manufacturers' catalogues with specifications of raceways including conduits, trunking etc. and related accessories,

Samples of each type of raceway and accessory.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Exact routing of conduits, trunking etc. with indication of boxes, accessories and expansion joints, size and type of conduits and boxes,

Typical assembly details of installation of trunking, trays, etc.

Construction details of pull boxes,

typical installation details including connection of conduits to metal enclosure, connection of flexible conduits, vapor-tight installations in cold rooms, weatherproof installations outdoors etc. and earthing connections.

PRODUCTS AND SYSTEMS

## 218:H CONDUITS AND ACCESSORIES

### 218:H1 RIGID HEAVY GAUGE STEEL CONDUIT

H105 MATERIAL: heavy gauge drawn and welded steel, threaded at both ends, to CEE 23, BS 4568 Part 1 and BS 31 Class B, with class 4 protection for rigid steel conduit, zinc coated inside and outside by hot-dip process.

H150 FITTINGS GENERALLY: threaded type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated. Fittings and components are to comply with CEE 23, BS 4568 Part 2 and BS 31.

H155 LOCKNUTS for securing conduit to metal enclosure are to be heavy hexagonal or castellated pattern, for fastening.

H160 BUSHINGS for terminating conduits are to be smooth rounded brass rings.

H170 MISCELLANEOUS FITTINGS including reducers, chase nipples, three piece unions, split couplings and plugs are to be standard fittings designed and manufactured for the particular application.

### 218:H2 RIGID STEEL CONDUIT

H201 INTERMEDIATE METAL CONDUIT (IMC): rigid high grade mild strip welded steel, hot dip galvanized over the entire length including factory made treads after cutting with organic corrosion resistant polymer inside coating and to US Federal Specification, UL 1242 and ANSI C80.6.

H203 IMC FITTINGS GENERALLY: threaded fittings and connectors and terminations with rigid coupling, concrete tight where required, and with red lead coated threads where site cut. Factory made bands are to be provided where site bending is not possible.

H205 ELECTRICAL METALLIC TUBING (EMT): welded steel, non-threaded type, galvanized externally and protected internally with corrosion resistant enamel, and to U.S. Federal Specifications, UL 797 and ANSI C80.3.

H250 EMT FITTINGS GENERALLY: threadless pressure type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated. Factory made bends are to be provided where site bending is not possible.

H220 CORROSION RESISTANCE: conduits used in corrosive atmospheres are to be copper silicon alloy, highly resistant to corrosion.

## 218:H3 FLEXIBLE STEEL CONDUIT

H305 MATERIAL: steel, cold rolled and annealed, non-threaded type, formed from continuous length of helically wound and interlocked strip steel, with fused zinc coating on inside and outside, and to BS EN ISO 9012.

H315 LIQUID-TIGHT FLEXIBLE CONDUIT is to have PVC jacket extruded over core.

H350 FITTINGS GENERALLY: threadless, hinged clamp type, galvanized or cadmium plated malleable cast iron. Fittings used in corrosive atmospheres are to be specially treated.

H355 STRAIGHT CONNECTORS: one piece body, female end, having hinged clamp and deep slotted machine screws for securing to conduit, male end having thread and locknut.

H360 ANGLE CONNECTORS of 45 or 90 degree and terminal connectors are to be as specified for straight connectors, except that body is to be two-piece with removable upper section.

## 218:H4 RIGID HEAVY GAUGE PVC CONDUIT

H405 MATERIAL: rigid unplasticized polyvinyl chloride with high impact and high temperature resistance, flame retardant, non-hygroscopic and non-porous, to CEE 26, BS 4607 and BS 6099, DIN 49016 or other equal and approved standards conforming to IEC 60423, 61386-1 and 61386-21.

H450 FITTINGS GENERALLY: unbreakable, non-inflammable, self extinguishing, heavy moulded plastic. Expansion couplings are to be telescoping double tube type, with at least two inner water-tight neoprene rings.

H460 ASSEMBLY: conduits, boxes and accessories are to be assembled by cementing, using manufacturer's recommended products and appropriate connectors or spouts. Where no spouts are available use smooth bore male PVC bushes and sockets.

## 218:H5 FLEXIBLE PVC CONDUIT

H505 MATERIAL: flame retardant, heat resistant, non-hygroscopic PVC, high resistance to impact, ribbed on circumference for flexibility.

H510 FITTINGS GENERALLY: unbreakable, non-inflammable, self extinguishing, heavy moulded plastic. Expansion couplings are to be telescoping double tube type, with at least two inner water-tight neoprene rings.

## 218:H6 STEEL CONDUIT ACCESSORIES

H605 SLEEVES THROUGH OUTSIDE WALLS: cast iron, with end and intermediate integral flanges, and internal diameter larger than diameter of through-conduit. Length is to correspond to wall thickness. Space between sleeve and conduit is to be packed with oakum to within 50 mm of both faces of wall, remainder of sleeve packed with plastic compound or lead, held in place by heavy escutcheon plates bolted at both ends to flanged ends of sleeve. Alternatively, sleeves are to be O.Z/Gedney, Type WSK or other equal and approved, with cable or conduit bolted pressure sealing components.

H615 SUPPORTS AND HANGERS: galvanized malleable cast iron straps or structural steel sections with hot dip galvanized bolts and nuts.

H620 EXPANSION JOINT FOR EMBEDDED STEEL CONDUITS - TYPE A: watertight, flexible conduit with end fittings to receive fixed conduits. Length is to allow movement within range of joint and is not to be less than 20 times diameter of conduit. Conduit is to be covered with thick rubber tubing with 5 mm minimum gap all around tube. Bonding jumper with earth clamp is to be electrically connected both sides of joint. Fitting is to be O.Z/Gedney, Type DX or other equal and approved.

H630 EXPANSION JOINT FOR EXPOSED STEEL CONDUITS - TYPE B: sleeve with fittings to permit telescoping of one conduit into sleeve. Movable conduit is to be fitted with watertight bushing. Joint is to be weatherproof, of galvanized malleable iron or steel. Bonding jumper with earth clamp is to electrically connect both sides of joint. Expansion fitting is to be O.Z/Gedney, Type EX or other equal and approved.

H640 EXPANSION JOINT FOR EXPOSED STEEL CONDUITS - TYPE C: PVC sheathed flexible steel conduit terminating in pull boxes and securely fixed on each side of structural expansion joint. Bonding jumper is to electrically connect both sides of joint.

H650 TAGS: 50 mm diameter steel with indented lettering, rust inhibiting treatment and baked enamel finish.

## 218:X WIREWAYS AND CABLE SUPPORTING SYSTEMS

### 218:X1 CABLE TRAYS

X105 COMPONENTS are to include cable trays (as shown on the Drawings), bends, elbows, tees, couplings and plates, rubber grommets, hangers, bracket supports and other system accessories required for safety and protection of the cable installations.

X108 TRAYS are to be provided to carry the maximum load of cables with a factor of safety 300%.

X110 TRAYS are to be heavy gauge perforated sheet steel, hot-dip galvanized after manufacture, minimum 1.5 mm thick, with sides not less than 45 mm deep, and as shown on drawings. Fittings are to be same material as tray. Covers, where shown on the Drawings, are to be minimum 1.0 mm thick galvanized sheet steel, Snap-On or bolt type, forming a rigid assembly with the tray.
X120 GALVANIZING is to be in accordance with EN ISO 1461, applied after fabrication with local coat thickness of 45 µm and mean coat thickness of 55 µm.

X123 BOLTS AND SCREWS are to be cadmium plated or electrolytically galvanized.

X130 SIZES: trays are to be standard metric sizes, 150, 300, 450, 600 and 900 mm wide, and at least 2.44 m (8 ft) length of section. Size of tray is to be determined by number and sizes of cables in accordance with the Regulations and/or as shown on the Drawings. Tray is to have strength and rigidity to provide support for cables contained within. Deflection between supports is not to exceed 1/350 under full loading capacity.

X140 EARTHING CONNECTOR for plastic coated trays is to be provided on each coupling between adjacent sections.

### 218:X2 WIRING AND CABLE TRUNKING

X205 COMPONENTS are to include wire way base, clip-on covers, couplings, end plates, wall flanges, panel to trunking rubber grommets, elbows, tees, adaptor plates and necessary hangers, supports and accessories.

X210 STEEL TRUNKING: to BS 4678 Part 4, galvanized sheet steel, minimum 1.5 mm thick, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.

X220 PVC TRUNKING: to BS 4678 part 4 high impact, heavy duty, self-extinguishing, rigid PVC with grooved double locking action of the clip-on cover. Design is to be approved by the Engineer before ordering materials. Trunking is to be capable of receiving functional slot-in hangers and demountable separators to segregate wiring systems as needed.

X225 SIZES: as required to accommodate number of conductors permitted by the Regulations and/or as shown on the Drawings.

218:X3 WEATHERPROOF WIRING AND CABLE TRUNKING

X305 TYPE: hot-dip galvanized sheet steel trunking of 1.5 mm thickness (minimum) and cover, 1 mm thick, to BS4678 Part 1 for trunking and BS3834-4 & BSEN 11135 – 1461 for galvanizing, .
X310 CONSTRUCTION: trunking is to have outwardly turned flanges to receive cover, and internal sleeve coupling between sections, permitting cutting of trunking on site.

X315 GASKETS: neoprene bonded cork gaskets are to be fitted throughout, between any two attached surfaces.

X320 SCREWS: removable flanged covers are to be secured with galvanized steel holding screws.

218:X6 SKIRTING TRUNKING

X605 TYPE: comprising wireway base, snap-on cover, couplings, end plates, wall flanges, elbows, tees, adapters, if required, and necessary clamps, hangers, supports and accessories. Wires and cables are to laid from front and held in place by clamps.

X610 STEEL SKIRTING TRUNKING: sheet steel, 1.5 mm minimum thickness, protected internally and externally with corrosion resistant finish such as zinc or cadmium with top coat of enamel.

X620 UPVC SKIRTING TRUNKING: high impact resistant, flame retardant UPVC (unplasticized polyvinyl chloride) to BS 476 Part 4.

X630 PARTITIONS: trunking is to be partitioned continuously into compartments for separate circuits. Size of each compartment is to be determined by size and number of conductors housed, in accordance with the Regulations and/or as shown on the Drawings.

X635 DIMENSIONS: as shown on the Drawings and as required to accommodate specified wiring devices.

## FIELD AND INSTALLATION WORK

### 218:1 CONDUIT AND WIREWAYS GENERALLY

1101 USE: unless otherwise specifically indicated all light and power circuits, communications, signal and low current systems wiring are to be drawn inside conduits or wireways up to the various electric power consuming equipment as shown on the Drawings.

1110 SEPARATE CONDUITS AND WIREWAY installations are to be used for medium voltage cables, low voltage feeders and sub-feeders, normal light and power circuits, emergency light and power circuits and communication, signal and other low current systems wiring. Cables of different voltages are not to be mixed within the same conduit or wireway as per the regulations.

1201 BOXES: junction, pull and splice boxes of ample capacity are to be provided as indicated or required. Boxes are to remain permanently accessible.

1301 TOOLS AND ACCESSORIES for forming and installing conduit and wireway systems are to be purpose made for the particular application and used in accordance with manufacturers' instructions.

1401 FIXING: conduits and wireway installations are to be concealed as much as possible.

1501 SIZES of conduits and wireways, not shown on the Drawings, are to be selected in accordance with the Regulations and in relation to the number and size of conductors and the space factor as recommended by the regulations. Minimum size of conduit for all applications is to be 20 mm diameter, unless otherwise shown on the Drawings.

1601 MECHANICAL CONTINUITY: conduits and wireways are to be effectively joined together and connected to electrical boxes, fittings and cabinets to provide firm mechanical assembly. Earthing jumpers are to be installed on steel conduits where required to ensure effective electrical continuity irrespective of whether a separate protective earth conductor is required or not.

1655 METAL CONDUITS AND ENCLOSURES are to be mechanically fastened, and to be connected to electrical boxes, fittings and cabinets to form low electrical resistance continuity and firm mechanical assembly.

1660 DISSIMILAR METALS: use of dissimilar metals is to be avoided throughout the system to eliminate possibility of electrolysis. Where dissimilar metals are in contact, treat surfaces with corrosion inhibiting compound before assembling.

1665 MISCELLANEOUS FITTINGS such as reducers, chase nipples, 3 – piece unions, split couplings and plugs that have been specifically designed and manufactured for their particular application are to be installed as necessary.

1675 CONDUITS are to be tested with a mandrel. Conduits that reject a mandrel are to be replaced. Restore conduit and surrounding surfaces to original condition.

## 218:2 CONDUITS AND WIREWAYS APPLICATIONS AND INSTALLATION GENERALLY

2102 CONDUITS AND WIREWAYS INSTALLATIONS are to be as described below, unless otherwise shown on the drawings or described in the particular section of the Specification.

2105 RIGID HEAVY GAUGE STEEL CONDUIT is to be used for all exposed installations comprising lighting, power, low current, communication and signal system wiring, including mechanical equipment rooms, electrical equipment rooms, service areas, and the like. Use rigid steel conduit in areas classified as hazardous explosive area. Flexible conduit is not acceptable.

2110 ELECTRICAL METAL TUBING (EMT) is to be used for exposed installations over false ceilings when the false ceiling is used as a return plenum.

2115 ELECTRICAL METAL TUBING (EMT) is to be used for exposed and above false ceiling wiring installations used in conjunction with exit and escape route lighting/ central battery circuits, fire alarm & security installations.

2120 ELECTRICAL METAL TUBING (EMT) is to be used for all installations in parking floors, kitchen, laundry & solid waste rooms.

2125 CONDUIT TERMINATION in sheet metal enclosures is to be fastened by lockouts, and terminate with bushing. Install locknuts inside and outside enclosure.

2131 RIGID HEAVY GAUGE PVC CONDUIT is to be used for lighting and power circuits, low current, communication and signal system wiring, where embedded in concrete masonry earth, underfloor, except where otherwise shown on the Drawings or described in the particular section of the Specification.

2141 RIGID HEAVY GAUGE PVC CONDUIT is to be used above false ceilings for lighting and power circuits, low current, communication and signal system wiring, when the false ceiling is not used as return plenum – and in furred walls. Use flexible PVC conduits from outlet boxes to fixtures in conjunction with the use of PVC conduits.

2145 FLEXIBLE CONDUIT of same material as corresponding conduit system is to be used for connection to motors, vibrating and non-rigidly fixed equipment and to fixtures installed in false ceilings.

2151 FLEXIBLE STEEL CONDUIT is to be used in movable partitions and from outlet boxes to fixture over false ceilings when used as a return plenum. Conduits are to be liquid tight in damp areas.

2155 LIQUID-TIGHT FLEXIBLE STEELGALVANIZED CONDUIT is to be used in one or more of the following conditions:

Exterior location

Moist or humid atmospheres where condensate can be expected to accumulate.

Corrosive atmosphere

Subjected to water spray or dripping oil, water or grease.

2161 EXPOSURE TO DAMAGE: conduit considered to be subject to undue risk of damage by shock or corrosion is to be brought to the attention of the Engineer. Copper silicone alloy tubes may be used in corrosive atmospheres.

2165 CROSSING: conduits are not to cross pipe shafts, vents or openings.

2171 CLEARANCES: install conduits at least, 150 mm clear of and preferably above pipes of other non- electrical services. (Hot water pipes, etc.). Wherever possible, install horizontal conduit and wireways runs above water and steam piping.

2181 SLEEVES: obtain approval for positioning sleeves where conduits pass through reinforced concrete. Additional opening may be allowed in finished slabs, but are to be drilled. Fix sleeves rigidly to maintain position and alignment during construction work.

2201 WATERPROOF CONSTRUCTION: conduits are not to cross waterproof construction unless permitted by the Engineer. Specially designed and approved fittings are to be used.

2205 EXPANSION FITTINGS: provide in each conduit and wireways run every 30 meters, or wherever structural expansion joints are crossed.

2205 MAKE GOOD all holes for conduits passing through walls, floors and ceilings with cement or similar fire-resisting material to full thickness.

2215 BENDS: conduit runs between outlet and outlet, fitting and fitting or outlet and fitting are not to contain more than the equivalent of 2 quarter bends (180 degree total).

2221 BENDING is to be made without damaging conduit or tubing and without reducing internal diameter. Methods of field bending are to be approved.

2231 CUT ENDS are to be reamed to remove burrs and sharp edges.

2241 CONDUITS ENTERING COLD STORES are to be made vapour tight, so that vapour from outside cannot enter conduit.

2251 DRAINING: arrange conduits so that condensed moisture can drain to screwed plug at lowest point.

2261 BEFORE WIRING, conduits are to be swabbed through. Do not draw cables into any section of system until conduit and draw boxes are fixed in position, and the raceway installation is completed.

2271 CAPPING: conduits are to be properly capped until wiring conductors are drawn in.

2281 CONDUIT AND FITTINGS INSTALLED OUTDOORS are to be watertight and highly resistant to corrosion. Use appropriate fittings, threaded and hubbed boxes, gaskets with screw on covers and the like.

2291 TERMINATIONS: do not terminate or fasten rigid conduits to motor frame or base.

2301 LENGTH AND RADIUS OF FLEXIBLE CONDUIT used for motors and vibrating equipment are to permit bending of feeder cables without damage to conductor or insulation.

2311 FLEXIBLE CONDUIT FOR SLIDE RAIL MOUNTED MOTOR is to have sufficient slack to allow for movement of motor over entire slide rail length.

2321 PULLING WIRE: install 3 mm galvanized stranded steel wire or equivalent strength cord with wooden blocks fastened at ends, in empty service conduits (power, low current and signal).

2331 STANDARD ELBOWS are to be used for conduit sizes over 40 mm. For smaller sizes, field bends may be used provided no damage occurs to conduit.

2341 TAGS: fit to conduits entering or leaving floors, walls or ceilings for identification of conduit and circuits. Tags are also to be placed at suitable intervals throughout the system.

2351 NON – FERROUS CONDUIT is to be installed for circuits operating above 60 Hz.

## 218:3 STEEL CONDUITS

3051 TERMINATION: conduit entering sheet metal enclosure or outlet boxes, when not terminated in a threaded hub, is to be securely held in place by two lock-nuts, placed inside and outside enclosure, and terminated with an insulating bushing.

3101 RUNNING THREADS: do not use running threads at joints and terminations, but use 3-piece unions or split couplings.

3201 ADDITIONAL THREADED CUTS on galvanized steel conduits are to be painted with zinc based coating resistant to corrosion.

3301 DAMAGE TO PROTECTIVE COATING of conduits is to be repaired to original degree of protection.

3351 OUTDOOR MOUNTED STEEL CONDUIT: apply anti-corrosion coating of zinc-chromate based paint and two weather resistant finish coats of enamel, of approved colour, or other equal and approved coating.

3401 GALVANIZED CONDUIT RUN IN SCREED is to be painted with heavy coat of emulsified bitumen.

3451 GALVANIZED STEEL CONDUITS BURIED IN GROUND or placed in wet or damp locations are to be coated with two heavy coats of hot bitumen. Conduits are to be covered by at least 600 mm of earth if buried in planting soil and by 300 mm if under walkway.

3501 PLUGS: use hardwood or threaded iron plugs for blanking ends of steel conduit not used.

218:4 PVC CONDUITS

4051 COUPLING OF CONDUIT and/or termination into spouted fittings are to be made watertight and permanent using special cement.

4101 TERMINATION: connect conduits terminating in switchgear, fuseboards, trunking, adaptable boxes or other non-spouted enclosures etc. with smooth bore male PVC bushes and sockets.

4151 ENDS OF CONDUIT and conduit fittings are to be cleaned and jointed using PVC cement recommended by manufacturer.

4201 SEMI-PERMANENT ADHESIVE: use in joints requiring expansion couplers.

4251 BENDS: conduits not exceeding 25 mm diameter may be cold bent using bending springs. Conduits over 25 mm are to be hot bent by an approved method.

## 218:5 EMBEDDED CONDUITS

5051 CONDUITS IN CONCRETE SLABS: place conduits parallel or at right angles to main reinforcing steel, between bottom reinforcing and top reinforcing steel. Fasten conduits to reinforcing steel by positive wire, fasteners at the proper distance from the concrete face. Embedded conduit diameter is not to exceed 1/3 of slab thickness. Special cases shall be reviewed by the Engineer for a decision.

5101 CONDUITS IN PARTITIONS OR SIDE WALLS: horizontal or cross runs are to be avoided.

5251 PULL-BOXES are not to be used. If unavoidable, pull-boxes may be approved if located inconspicuously.

5301 CONDUITS IN FLOOR OF BEDS ON GRADE: encase in concrete, minimum thickness 50 mm or to thickness allowed by architectural detail.

5351 PVC CONDUITS IN REINFORCED CONCRETE STRUCTURES are generally to be installed after placing reinforcement and before concreting, if protected against damage, or are to be placed in grooves formed in the concrete, if approved.

## 218:6 EXPOSED CONDUITS

6051 CONDUITS ON WALLS: are to be run neatly, horizontally or vertically.

6101 SUPPORTS: use approved clamps, hangers or clips fastened by machine screws to expansion sleeves in inserts or to lead anchors.

6151 SPACING OF CLAMPS OR CLIPS for supporting steel conduits is not to be greater than:

| Conduit Size mm (inches) | Maximum Spacing of Supports metres (feet) |
|---|---|
| 20 (3/4) | 3.00 (10) |
| 25 (1) | 3.60 (12) |
| 32-38 (1-1/4 - 1-1/2) | 4.25 (14) |

| | |
|---|---|
| 50-63 (2 - 2-1/2) | 5.00 (16) |
| 75 (3) and larger | 6.00 (20) |

6161 SPACING OF CLAMPS OR CLIPS for supporting PVC conduits is not to be greater than:

| Conduit Size mm (inches) | Maximum Spacing of Supports metres (feet) | |
|---|---|---|
| | Conductors Rated 60 deg.C and below | Conductors Rated more than 60 deg.C |
| 20 (3/4) | 1.25 (4) | 0.60 (2) |
| 25-50 (1 - 2) | 1.50 (5) | 0.75 (2-1/2) |
| 63-75 (2-1/2 - 3) | 1.80 (6) | 0.90 (3) |
| 90-125 (3-1/2 - 5) | 2.00 (7) | 1.00 (3-1/2) |
| 150 (6) | 2.50 (8) | 1.25 (4) |

6251 BENDS AND FITTINGS: firmly fasten conduit at each side of bends and within 900 mm of each outlet box, junction box, cabinet or fitting.

6301 OUTLETS: do not run more than the permissible numbers of conduits to any surface wall outlet.

6351 EXPOSED CONDUIT WORK is to be installed so as not to interfere with ceiling inserts, lights or ventilation ducts or outlets.

## 218:7 CABLE TRAYS

7051 GENERAL: each run of cable tray is to be completed before installation of cables. Submit calculations taking into consideration the maximum load on cable trays with a factor of safety 300%.

7101 SUPPORTS AND BARRIERS: provide supports to prevent stress on cables entering or leaving tray. Cable trays extending through partitions and walls are to be protected by fireproof non-combustible barriers.

7201 TRAYS: remove sharp edges, burrs and projections and finish trays smooth. Fix trays using approved suspension rods or steel angle brackets at spacing not exceeding 1.5 m and generally as shown on the Drawings.

7251 CONNECTION FITTINGS on trays, such as tees, bends and crossings are to be purpose made with radii to permit cable-bending standards.

7301 MINIMUM CLEARANCE of 250 mm is to be maintained between top of tray and ceiling, beams and other services and between trays in multi-tier formation.

7401 CABLES: secure to trays with purpose made straps or saddles and arrange in one layer only, evenly spaced, or as shown on the Drawings, with minimum spacing of one diameter of the larger of the two adjacent cables or of a trefoil formation of single core cable circuit.

7501 EARTHING: do not use metal trays as earth continuity conductor. Connect trays by flexible tinned copper straps to nearest bare earthing conductor and at maximum 30 m spacing.

7551 CONNECTIONS TO EQUIPMENT: where cable trays connect to equipment, provide tray flanged fittings fastened to the tray and to the equipment. Support the tray separately. Do not carry the weight of the tray on the equipment enclosure.

7601 BARRIERS: where trays carry conductors of different systems, such as power, communications and data processing, or different insulation levels, such as 600V, 5000V, and 20, 000 V use separate cable trays. In case of absolute necessity, install insulating barriers to separate the systems after obtaining the Engineer's approval.

## 218:8 CABLE TRUNKING

8051 INSTALLATION: secure trunking of all sizes at intervals not exceeding 1200 mm. Joints are not to overhang a fixing by more than 500 mm.

8101 TRUNKING PASSING THROUGH WALLS AND CEILINGS is to have the cover fixed solidly for 25 mm either side of walls and for 150 mm either side of floors and ceilings.

8151 VERTICAL SECTIONS OF TRUNKING over 900 mm long are to have staggered insulated tie-off studs to support weight of cables.

8201 CABLING PROVISIONS: separation of power, low current and control circuits is to be by two channel trunking or by barriers inserted in trunking before installation of cables. Cable retaining straps are to be provided at not more than 600 mm centers. Openings in front of trunking are to facilitate drawing-in cables.

8251 COUPLING: trunking parts are to be mechanically and electrically coupled without causing abrasion to wiring.

8301 EARTHING: do not use metal trunking as earth continuity conductor. Provide protective conductor in accordance with Section 219 of the Specification.

## 218:10 UNDERGROUND DUCTS

10051 LAY AND ASSEMBLE ducts in accordance with Section 291 of the Specification.

# 219 EARTHING SYSTEM

## 219:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: complete installations to earth every source of energy and to provide protective earthing and equipotential bonding, based on the TN-S system arrangement, including:

Transformer substation earthing

Main distribution boards and electrical installations

Main earthing terminals or bars

Exposed conductive parts of electrical equipment

Road lighting earthing

Fence earthing

Extraneous conductive parts

Standby generator neutral earthing.

Clean earth for Low current and Communication systems

Earthing requirements specified in this Section may be supplemented by special requirements of systems described in other Sections.

A201 REGULATIONS AND STANDARDS: carry out work in accordance with the following:

BS EN 50364 and 60364-4-41 Electrical Installations in Buildings

latest edition of IEE Regulations for Electrical Installations in Buildings (BS 7671).

A251 DEFINITIONS OF TERMS used on the Drawings and in the Specification are as follows:

EARTH: conductive mass of the Earth whose electric potential at any point is conventionally taken as zero

EARTH ELECTRODE: conductor or group of conductors in initial contact with, and providing electrical connection to, Earth

EXPOSED CONDUCTIVE PART: any part which can be readily touched and which is not a live part, but which may become live under fault conditions

EXTRANEOUS CONDUCTIVE PART: any conductive part not forming part of the electrical installation such as structural metalwork of a building, metallic gas pipes, water pipes, heating tubes etc. and non-electrical apparatus electrically connected to them i.e. radiators, cooking ranges, metal sinks etc. and non-insulating floors and walls

PROTECTIVE CONDUCTOR: conductor used for some measure of protection against electric shock and intended for connecting together any of the following parts:

exposed conductive parts

extraneous conductive parts

earth electrode(s)

main earthing terminal or bar(s)

earthed point of the source(s)

ELECTRICALLY INDEPENDENT EARTH ELECTRODES: earth electrodes located at such distance from one another that maximum current likely to flow through one of them does not significantly affect the potential of the other(s)

MAIN EARTHING TERMINAL OR BAR: the terminal or bar provided for the connection of protective conductors, including equipotential bonding and functional earthing conductors if any to the means of earthing

EQUIPOTENTIAL BONDING: electrical connection to put exposed and extraneous conductive parts at a substantially equal potential

EARTHING CONDUCTOR: protective conductor connecting main earthing terminal or bar of an installation to earth electrode or to other means of earthing.

A301 EQUIPMENT DATA: prior to ordering materials, submit data for approval including, but not limited to, manufacturer's catalogues for earth rods, connecting clamps, earthing conductors, protective conductors, bonding conductors, connectors and other accessories, exothermic welding kits and tools etc., and samples of conductors as requested.

A302 QUALIFICATION DATA: For firms and persons specified in "Quality Assurance" Article to demonstrate their capabilities and experience. Include lists of completed

projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by Engineer.

A303 FIELD TEST REPORTS: Submit written test reports to include the following:

Test procedures used and test conditions.

Test results that comply with requirements.

Results of failed tests and corrective action taken to achieve test results that comply with requirements

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

- exact location of earth pits, rods and details of installation and connections
- exact routing of buried earthing conductors with indication of cross-section, depth of laying and covering
- cross sectional area of all earthing, protective and bonding conductors
- layout and details of earthing provisions at substations, generator rooms, switchgear, distribution panelboards etc., indicating fittings used, insulation, plates and marking, passage and routing of earthing conductors, conduit, sleeves, grooves, niches etc., giving sizes and dimensions of component parts.

A601 QUALITY ASSURANCE

Installer Qualifications: Engage an experienced installer who has specialized in installing lightning protection systems similar in material, design and extent to those indicated for this Project and whose work has resulted in installations with a record of successful in-service performance.

PRODUCTS AND SYSTEMS

## 219:X EARTHING SYSTEM (TYPE TN-S)

### 219:X1 GENERAL REQUIREMENTS

X105 COMPONENT PARTS of earthing system are to include the following:

- Main earthing terminals or bars,
- Earthing conductors,
- Protective conductors,
- Equipotential bonding conductors,
- Accessories and termination fittings, bonding, welding kits and other materials.

X110 EARTH ELECTRODE consists of a copper loop around the building and supplemented by a certain number of earth rods in selected locations. Overall resistance is to read 5 ohms.

X120 FUNCTIONAL EARTH ELECTRODE is to be provided separately from, but interconnected to, other earth electrode(s) through suitably rated (470 V) spark gap. Functional earth electrodes are to be used for earthing electronic equipment (communication equipment, digital processors, computers etc.) as required by the particular Section of the Specification and recommendation of manufacturer.

X130 MAIN EARTHING BAR is to be provided at point of service entrance or main distribution room, and as described in the Specification or shown on the Drawings, to which all earthing conductors, protective conductors and bonding conductors are to be connected. Two insulated main earthing conductors are to be provided, one at each end of the bar, connected via testing joints to the earth electrode at two separate earth pits. Conductor is to be sized to carry maximum earth fault current of system at point of application with final conductor temperature not exceeding 160 deg. C for at least 5 seconds. Main earthing conductors are to be minimum 120 mm2 or as otherwise required by the particular Section of the Specification.

X135 TESTING JOINTS (TEST LINKS) are to be provided, in an accessible position, on each main earthing conductor, between earthing terminals or bar and earth electrode.

X140 PROTECTIVE CONDUCTORS are to be separate for each circuit. Where protective conductor is common to several circuits, cross-sectional area of protective

conductor is to be the largest of the conductor sizes. Selection of sizes is to be in accordance with Table 54G of BS 7671.

X141 PROTECTIVE CONDUCTORS are not to be formed by conduit, trunking, ducting or the like. Where armoured cable is specified and armour is steel, it may be used as a protective conductor, if approved and if not otherwise shown on the Drawings.

X150 CONTINUITY OF PROTECTIVE CONDUCTORS: series connection of protective conductor from one piece of equipment to another is not permitted. Extraneous and exposed conductive parts of equipment are not to be used as protective conductors, but are to be connected by bolted clamp type connectors and/or brazing to continuous protective conductors which are to be insulated by moulded materials.

X155 EARTH FAULT LOOP IMPEDANCE: for final circuits supplying socket outlets, earth fault impedance at every socket outlet is to be such that disconnection of protective device on overcurrent occurs within 0.4 seconds, and for final circuits supplying only fixed equipment, earth fault loop impedance at every point of utilization is to be such that disconnection occurs within 5 seconds. Use appropriate tables and present same for approval by the Engineer (BS 7671: Table 41A Appendix 9 Regulation 543).

X160 SUPPLEMENTARY EQUIPOTENTIAL BONDING: all extraneous conductive parts of the building such as metallic water pipes, drain pipes, other service pipes and ducting, metallic conduit and raceways, cable trays and cable armour are to be connected to nearest earthing terminals by equipotential bonding conductors. Cross-section of protective bonding conductor is not to be less than half that of the protective conductor connected to respective earthing terminal and minimum 4 mm2.

X165 MAIN EQUIPOTENTIAL BONDING: main incoming and outgoing water pipes and any other metallic service pipes are to be connected by main equipotential bonding conductors to main earth terminal or bar. Bonding connections are to be as short as practicable between point of entry/exit of services and main earthing bar. Where meters are installed, bonding is to be made on the premises side of the meter. Cross-sections of conductors are not to be less than half that of the earthing conductor connected thereto, and minimum 6 mm2.

X170 IDENTIFICATION: connection of every earthing conductor to earthing electrode and every bonding conductor to extraneous conducting parts is to be labelled in accordance with the Regulations, as follows:

SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE.

X171 IDENTIFICATION: protective and earthing conductors are to be identified by combination of green-and-yellow colours of insulation or by painting bar conductors with these colours, as approved.

X172 IDENTIFICATION: source earthing conductor (or neutral earthing conductor) is to be identified along its entire length by continuous black insulation labelled 'neutral earthing'.

## 219:X2 TRANSFORMER SUBSTATION EARTHING

X205 MV SWITCHGEAR/Ring Main Unit are to have separate main earthing bar connected to framework or earth bar of each item by bare conductor and the earth-electrode by two insulated earthing conductors, one at each end of bar, via testing joints. Earthing conductor is to be minimum 50 mm2.

X215 LV SWITCHGEAR is to have separate main earthing bar connected to framework or earth bar of each item by bare conductor and the earth electrode at two extreme ends by two insulated earthing conductors through testing joints. Earthing conductor size is to be minimum 120 mm2.

X220 TRANSFORMER EARTHING TERMINAL is to be connected to LV main earthing bar by bare copper earthing conductor not less than 20 mm2 per 100 kVA of transformer rating, with a minimum of 35 mm2.

X225 TRANSFORMER NEUTRAL (STAR POINT) is to be connected by insulated earthing conductor (colour black) to LV side main earthing bar. Neutral earthing conductor is to be sized for maximum earth fault current for 5 seconds with final conductor temperature not exceeding 160 deg. C or sized not less than 30 mm2 per 100 kVA of transformer rating, and with a minimum of 50 mm2. Where a neutral is directly connected to earth electrode, an insulated disconnecting device is to be provided at the transformer.

X235 LIGHTNING ARRESTERS are to be directly connected to earth electrode, following the shortest path. Each lightning arrester is to be connected at a dedicated earth rod.

## 219:X3 EARTHING OF MAIN DISTRIBUTION BOARDS, PANELBOARDS, LIGHTING INSTALLATIONS AND WIRING ACCESSORIES

X305 MAIN EARTHING BAR is to be provided in main distribution room and connected to earth electrode by two insulated conductors (minimum 120 mm2) via testing joints.

X310 EARTHING BARS OF MAIN DISTRIBUTION BOARDS are to be connected, by bare earthing conductor, directly to main earthing bar at main distribution room and by protective conductor run with incoming feeder from respective supply point. Same shall apply for the SUB MAIN DISTRIBUTION BOARDS located in the buildings: Administration, Cargo, Custom, General Security & Harbor.

X315 DISTRIBUTION, LIGHTING AND POWER PANELBOARDS are to be connected by protective conductors run together with incoming feeder cable, connecting earth terminals in panelboards with respective main distribution board earthing bar.

X320 SOCKET OUTLETS are to be earthed by protective conductor looped around with the branch circuit and connected to earth terminal within socket outlet box and to which socket outlet terminal is to be connected.

X325 FINAL RING SUBCIRCUITS: protective conductor of every final ring subcircuit is to be in the form of a ring having both ends connected to earth terminal at origin of circuit in panelboard.

X330 LIGHTING FIXTURES AND OTHER EXPOSED CONDUCTIVE PARTS of electrical installations, such as switches, heaters, air conditioning units etc. are to be connected by protective earth conductors to earthing terminals of respective panelboards.

## 219:X5 MECHANICAL PLANT ROOMS AND FIXED MACHINERY

X510 MAIN EARTHING BAR OR LOOP is to be conveniently located in mechanical plant rooms, and connected by earthing conductors to exposed conductive parts of motor control centre at its earthing bar, and to motors, switches and other electrical equipment etc. at their earthing terminals, using 20 x 2 mm bare copper strips or 35 mm2 bare copper conductor (minimum size) or as required to carry maximum earth fault current for 1 second with final conductor temperature not exceeding 200 deg. C. Conductors are to be securely fixed, recessed in floor grooves or niches, or fixed to walls by appropriate staples. Earth bar or loop is to be securely fixed to building wall with copper or brass saddles.

X515 MAIN EARTHING BAR OR LOOP is to be connected at two extremely separate points to earth electrode, directly through two test joints by insulated earthing conductors, or connected to main earth bar by protective conductors.

X525 MOTOR AND OTHER EQUIPMENT EARTH TERMINALS are to be connected also by protective earth conductors of each branch circuit to earth terminal/bar at motor control centre, panel or distribution unit.

## 219:X6 ROAD LIGHTING

X610 EARTHING CABLES: Where armoured cable is specified and armor is steel, it is used as a protective conductor and looped into column earthing terminals. The last column or spur is to be bonded via an earthing bolt to a single 16 mm diameter copper covered steel rod, 2.5 m long, driven into ground adjacent to column.

X620 Connections between rods and earthing conductors are to be made by the exothermal process producing a fused joint and covered with “DENSO” tape. Bolted connections may be used for connection to removable items of equipment only.

## 219:X7 SIGNAL AND COMMUNICATION SYSTEMS

X710 CLEAN EARTH GROUNDING or low noise earth shall be provided as required, to ensure that the level of induced or conducted interference from external sources, including the facility power grounding system, does not produce incidence of malfunction of the equipment, which is unacceptable for the operating system.

X720 CLEAN EARTH GROUNDING SYSTEM shall be connected to the power grounding system.

X730 CLEAN EARTH GROUNDING CABLES shall not be run parallel with other grounding cables or power cables.

X740 CLEAN EARTH GROUNDING SYSTEM shall comply with IEC 60950 and BS EN 50310. Clean earth grounding pits shall be separated from other earthing pits by a distance of at least 1800mm. In general, clean earth grounding shall be provided for data system, telephony and other low current/communication systems.

X760 CLEAN EARTH GROUNDS shall have an earth impedance of less than 1 ohm.

## 219:X8 EARTHING OF FENCES

X810 METALLIC FENCES shall be separately earthed unless they come within 1.8 m of any equipment or structure above the surface of the ground, which is connected to the main earthing system. If the separation of 1.8 m cannot be obtained the fence shall be bonded to the earthing system.

X815 EARTHING OF A FENCE shall be provided by connecting certain metallic fence posts to an earth rod by a copper conductor. The earth rod shall be driven adjacent to the posts inside the fence line to a depth of not less than 3.0 m. Where no metallic posts are provided, the earth rods shall be connected directly to the metal wires, mesh or other components of the fence.

X820 BONDED FENCES: Fences which need to be bonded to the main earthing system of the installation shall be connected by copper conductors to the nearest accessible point on the main earthing system at each point where the fence comes within 1.8 m of any electrical equipment. Bonds shall also be made to each corner post, below the outer phase conductors of overhead line connections passing over the fence, at each gate and at intervals of not more than 100 m.

X825 BONDING OF FENCE COMPONENTS:

1. Fences made up of bolted steel or other metallic components do not require bonding between components. Where such fences have non-metallic components bonds shall be installed to maintain continuity between metallic components. Reinforced concrete components shall be treated as being non-metallic.
2. Longitudinal wires for supporting other fence components or for anti-climbing guards and the wires of chain link shall be directly bonded to each fence earth electrode or to each bond to the main earthing system.
3. Metallic components on masonry, brick, concrete or similar boundary wall shall be treated in the same manner as metallic fences.
4. Wire fence components coated for anti-corrosion protection or PVC coated fence shall be earthed in accordance with this Clause.

X830 GATES: The fixed metallic components on both sides of the gate shall be directly bonded together by a copper conductor installed under the surface of the access way. Flexible conductors shall be installed to bond the moving parts of the gates to the metallic fixed parts. An earth rod or a bond to the main earthing system shall be installed at each gate.

X840 POTENTIAL CONTROL OUTSIDE FENCES:

1. Where the approved design calculations show that the touch or step potentials outside the fence or boundary wall would otherwise be excessive, bare copper conductors shall be buried in the ground outside the fence or boundary wall at such depths and spacing as are to be shown in the approved design calculations to give acceptable touch and step potentials. The conductors shall form complete rings surrounding the installation and each ring shall be bonded to the adjacent ring and to the fence at each corner.

2. If the boundary fence or wall is substantially non-metallic the rings of conductors shall be bonded to the main earth system at each corner of the site and at intervals of not more than 100 m. Any metallic components on such boundary fences or walls shall be bonded to the earthing system in accordance with this Specification.

3. If the boundary fence is metallic and is not within 1.8 m of any part of the main earthing system or equipment bonded thereto the fence and outer conductor rings shall not be connected to the main earthing system unless the approved design calculations show otherwise.

4. Any meshes formed by bonding the outer conductors to the main earthing system shall be sub-divided by additional conductors, if required, to give acceptable touch, step and mesh potentials.

X850 CONDUCTORS: All conductors used for earthing and bonding the fences and components and for outer rings shall have a cross-sectional area of not less than 185 mm2 copper.

219:X9 MATERIALS AND PRODUCTS

X910 BURIED EARTH CONDUCTORS: bare annealed copper strip conductors 25 x 2.5 mm, or annealed stranded copper conductors 70 mm2 cross-section.

X925 EARTHING CONDUCTORS: insulated or bare copper conductor as described in the Specification for the particular application.

X930 TESTING JOINTS (TEST LINKS): copper or copper alloy, with bolted end connections, disconnectable by use of a tool, and suitably sized for earthing conductors or earth bar connection. Links are to be fixed to porcelain or other approved insulating supports. Contact surfaces are to be tinned.

X935 PROTECTIVE CONDUCTORS: single core stranded annealed copper, PVC insulated cables, having rated insulation grade compatible with circuit protected, or to be a conductor forming part of a multi-core cable, colour coded.

X940 MAIN EARTHING BAR: hard drawn copper, 40 x 4 mm where formed into a closed loop, and 50 x 6 mm where open ended. Earth bar is to be labelled 'Main Earth Bar' and is to be drilled, for connection of conductors, at a spacing not less than 75 mm, and is to be supplied with copper alloy bolts, nuts and washers and wall mounting insulators.

X950 PROTECTIVE BONDING CONDUCTORS: bare copper strip conductor, annealed stranded copper cable or flexible strap (flexible braid) of cross-sectional area as described in sub-section 219: X1 hereof.

X960 EARTHING ACCESSORIES: copper or copper alloy, purpose made, of approved design, compatible with points of connection, and of adequate cross-section and current carrying capacity. Connectors and clamps are to be bolted type. Bolts, nuts and washers are to be high quality phosphor bronze or copper silicon alloys.

## FIELD AND INSTALLATION WORK

### 219:1 INSTALLATION

1051 CONTINUITY: ensure that complete earthing system is electrically continuous and mechanically secure.

1201 BURIED EARTHING CONDUCTORS are to be laid at a depth not less than 0.8 m from ground surface.

1251 EARTHING CONDUCTORS are to follow shortest path between earth rods and main earthing terminals or bars, and are to run in PVC conduit (duct) fastened to building structure by approved supports and extending 0.2 m above level, and are to be protected against mechanical damage and corrosion.

1301 PROTECTIVE CONDUCTORS: separate protective conductors, which are not part of a cable, are to be fixed on same support or drawn into same conduit as circuit conductors.

1401 PROTECTIVE BONDING: remove any non-conductive paint, enamel or similar coating at threads, contact points and surfaces and ensure that bonding is made by fittings designed to make secure bonds.

1501 PROTECTION AGAINST CORROSION: protect bolted connections against corrosion either by filling with vaseline or coating with a special anti-corrosion compound and proper capping.

1601 CONNECTIONS: earth connections are to be readily accessible. If inaccessible earth connection is permitted, approved exothermic welding or brazing technique is to be employed.

1602 CONNECTIONS: where earth connections between dissimilar metals must be made, use bimetallic fittings and protect by coating with moisture resisting bituminous paint or compound, or by wrapping with protective tape to exclude moisture.

219:2 TESTS ON SITE AND RECORDS

2101 COMBINED RESISTANCE of earth electrodes is to be measured during dry season and checked against specified resistance.

2151 ELECTRICAL CONTINUITY of all earthing and protective conductors including main and supplementary equipotential bonding conductors is to be checked.

2201 EARTH FAULT LOOP IMPEDANCE of all circuits is to be measured and checked against calculated impedance figures.

2251 OPERATION of residual current protective devices is to be checked.

2301 RECORDS: submit the following:

- scaled drawings, as-installed, showing actual layout and specification of all components of earthing system,
- nature of soil and any special earth arrangements, etc.
- date and particulars of soil conditioning method and agents if used,
- test conditions and results obtained.

# 220 PHOTOVOLTAIC ENERGY SYSTEM

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Electrical Works is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification and all other related specification sections.

### 1.2 SUMMARY

A. Section Includes:

1. PV modules.
2. DC string combiner and monitoring boxes
3. Inverters.
4. Mounting structures.

### 1.3 DEFINITIONS

A. IP Code: Required ingress protection to comply with IEC 60529.

B. MPPT: Maximum power point tracking.

C. PV: Photovoltaic.

D. STC: Standard Test Conditions defined in IEC 61215.

E. NOCT: Normal Operating Cell Temperature.

F. Digital Twin: An interactive virtual replica of a physical asset, such as a building, a facility, a district or a group of infrastructure utilities, that dynamically reflects the real-time conditions of the asset components on an integrated data environment, allowing simulations, predictions, cost analysis, budgeting, asset tracking, energy management.

### 1.4 SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for PV panels.

2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Seismic Qualification Certificates: For equipment, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation. Include qualification data for testing agency.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

C. Sustainable Design Submittals: All related Sustainable Product Data as detailed in Division 01 Sustainability sections, as applicable.

D. Shop Drawings: Provide shop drawing including but not limited to the following:

1. Plans, elevations, sections, and mounting details.
2. Details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Detail fabrication and assembly.
4. Detailed single line diagrams for power, control, communications, grid interconnection details and earthing system
5. Earthing system layouts and details.
6. Site plan including interconnecting roads for ground mounted systems.
7. Cable trenches details.

E. Point-wise compliance statement to the specifications, duly signed by the manufacturer/ manufacturer’s authorized representative and the contractor.

F. Detailed system energy yield performance simulation using suitable software results, indicating all types of anticipated losses and taking into consideration the site characteristics and shading from nearby buildings/objects.

G. Test and Evaluation Reports: Submit certified test reports showing compliance with specified performance characteristics and physical properties.

H. Manufacturer's Instructions: Submit manufacturer's storage and installation instructions. Documents shall comply with IEC 61730 requirements.

I. Qualification Statements:

1. Submit letter of verification for Manufacturer's Qualifications.
2. Submit letter of verification for Installer's Qualifications.

J. Field quality-control reports.

K. Sample Warranty: For manufacturer's special materials and workmanship warranty and minimum power output warranty.

L. Operation and Maintenance Data: Include in operation and maintenance manuals as specified in Division 01 and to the satisfaction of Employer’s requirements.

## 1.5 QUALITY ASSURANCE

A. Products, materials and equipment shall demonstrate compliance with requirements specified in related specification sections.

B. Qualifications:

1. Manufacturer:

   a. Having minimum of 5 years’ experience in manufacturing components similar to or exceeding the Project’s requirements.
   b. Having sufficient capacity to produce and deliver required materials without causing delay in work.
   c. Capable of providing field service representation during construction.
   d. Manufacturing facility certified to ISO 9001 and to ISO 14001.

2. Installer:

   a. Experienced installer with 5 years minimum experience in PV installations, with a proven experience in PV system installations.

C. Local Representative: Provide evidence that proposed equipment manufacturer has a locally established and authorized organization which can be called upon for professional advice and maintenance as may be required, and which can immediately supply spare parts to support day to day and emergency maintenance requirements. Failure to satisfy Engineer may disqualify a manufacturer.

D. Mock-Up: Construct mock-up as follows:

1. Purpose: Construct showing solar electric modules and related system components to judge quality of work, choice of substrate or superstrate, and operation of equipment and material application.
2. Dimensions and Process: Construct the required dimensions as directed by the Engineer, using proposed procedures, colors, textures, finishes and quality of work.
3. Locate where directed by the Engineer.
4. Do not proceed with work prior to receipt of written acceptance of mock-up.
5. When accepted, mock-up will demonstrate minimum standard of quality required for this work. Approved mock-up may, or may not, remain part of finished work, as directed by the Engineer.

E. Standards: Comply with the following standards:

1. Electrical systems shall conform to the latest edition of BS7671 - "Requirements for Electrical Installations - IET Wiring Regulations", where not in contradiction with Local Regulations.
2. IEC 61646 : Thin-film terrestrial photovoltaic (PV) modules - Design qualification and type approval
3. IEC 61215 - Crystalline silicon terrestrial photovoltaic (PV) modules — Design qualification and type approval
4. IEC TS 62804-1: Photovoltaic (PV) modules-Test methods for the detection of potential-induced degradation - Part 1: Crystalline silicon.
5. ANSI/UL 1703: Standard for Flat-Plate Photovoltaic Modules and Panels.
6. EN 50380 - Datasheet and nameplate information for PV modules.
7. IEC 61727 - Photovoltaic (PV) systems - Characteristics of the utility interface
8. IEC 62116 - Utility-Interconnected PV Inverters – Test procedure of Islanding Prevention measures
9. IEC 61730 – Parts 1&2: PV module Safety Qualification.
10. IEC 62109- Parts 1&2 - Safety of power converters for use in PV power systems.
11. IEC 62446-1 – PV systems Testing and Commissioning.
12. IEC 61853-1 - PV module performance testing and energy rating.
13. IEC 62548 - PV Arrays design requirements.
14. IEC TS 62738: Ground-mounted photovoltaic power plants - Design guidelines and recommendations.
15. IEC 61724 – PV System Performance Monitoring Guidelines for measurement, data exchange and analysis.
16. IEC 60068-2-68 : Environmental testing - Part 2-68: Tests - Test L: Dust and sand.
17. IEC 61701: Salt mist corrosion testing of photovoltaic (PV) modules.
18. IEC 62716: Ammonia corrosion testing of photovoltaic (PV) modules.
19. ENA Standard G59/2.
20. BS 7430 - Code of Practice for Protective Earthing of Electrical Installations.
21. IEC 62305 – Protection Against Lightning.
22. IEC 61000 – Electromagnetic Compatibility (EMC).
23. Nominal characteristics of equipment forming part of the electrical works shall be specified to conform to the relevant standards of the International Electro-technical Commission (IEC) or other equivalent international standards.

F. PV installation shall comply with IEC 60364-1 general requirements along with the particular requirements related to PV installations as listed in IEC 60364-7-712.

G. Products shall be sourced either directly from manufacturer, or from authorized agent/representative.

H. Sustainability Requirements: Comply with indicated Codes and sustainability targets and requirements specified in Division 01 Sustainability sections, as related to renewable energy.

## 1.6 DELIVERY, STORAGE, AND HANDLING

A. Install certified “shock-guards’ on the equipment before shipping from the factory and shall be retained in place till unpacked at site and inspected by Engineer, to ascertain whether the “shock-guard” has been activated by any shock/impact during shipment.

B. Deliver materials in fully enclosed vehicles and in accordance with manufacturer's written instructions.

C. Deliver materials in manufacturer's original packaging with identification labels intact and in sizes to suit Project.

D. Receive, handle and store materials in spaces having controlled environments in conformance with the manufacturers’ instructions in relation to ambient temperature and humidity conditions for non-operating equipment.

## 1.7 COORDINATION

A. Coordinate layout and installation of PV modules and components with roof skin and other construction and electrical work, including conduit, piping, equipment, adjacent surfaces, raceways, electrical boxes and fittings, and cabling/wiring work.

B. Maintain required workspace clearances and required clearances for equipment access.

C. Coordinate size and location of mounting structures.

## 1.8 PROJECT CONDITIONS

A. Equipment shall be designed and derated for continuous and trouble free service under the climatic conditions specified in related specification sections.

B. Equipment, apparatus, material accessories outdoors shall be corrosion and salinity proof. UV stabilized requirement shall be applied for outdoor installations and their surface finish and due certification shall be provided by manufacturer as necessary.

## 1.9 EXTRA MATERIALS

A. Furnish extra materials described below that match product installed and that are packaged with protective covering for storage and identified with labels describing contents. Deliver extra products to the Employer.

1. Provide spare parts as per manufacturer recommendations.
2. Photovoltaic Panels: 1% of each type and rating installed.
3. Inverters: 1% of each type and rating installed.

4. Robotic cleaning system batteries: 5% of each type and rating installed. Minimum one unit of each type and rating installed.
5. 2% PV panels' MC-4 connectors with minimum number of 50 connectors.
6. 2% String Fuses with minimum number of 5 fuses.
7. 3 DC fuses for each inverter.
8. Temperature sensors and cooling fans
9. 2 Pyranometers per plant.
10. 2 reference cell per plant.

B. Tools and Instruments: Provide tools and instruments required for normal routine inspection, testing, operation and general maintenance, as recommended by the manufacturer.

## 1.10 WARRANTY

A. Manufacturer's Warranty: Submit a written warranty signed by the manufacturer agreeing to repair, restore or replace any defective equipment specified in this section during the specified warranty period

1. PV modules: PV modules shall be provided with Product and Power output warranties as follows:

   a. Product warranty: Ten (10) years product warranty from the date of Substantial Completion. Warranty to include but not limited to: modules, junction boxes, bypass diodes and cables and connectors associated with the modules.
   b. Power output warranty: For a minimum of 25 years from the date of Substantial Completion. Guaranteed power output performance shall ensure that the first year degradation in modules power doesn't exceed 2% of modules nominal rated power at STC and with linear annual degradation afterwards such that the power output after 25 years of operation is 85% of the nominal power rating at STC as a minimum. Any deviation from the guaranteed performance shall be compensated by the Contractor.

2. Inverters, string combiner boxes and Plant controllers: Five (5) years from the date of Substantial Completion. Supplier must provide an extendable warranty option. Proceeding with the extended warranty option shall be at the Employer's discretion.

3. Mounting Structures: Ten (10) years from the date of Substantial Completion.

4. All other system components including but not limited to the below components shall be provided with two (2) years warranty from the date of Substantial Completion:

   a. Weather stations including Pyranometers and reference cells.
   b. Tracking system.

# PART 2 - PRODUCTS

## 2.1 SEISMIC PERFORMANCE REQUIREMENTS

A. Seismic Performance: Supports and seismic restraints for equipment, accessories, and components shall withstand the effects of earthquake motions determined in relevant specification sections.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will be fully operational after the seismic event".

## 2.2 SYSTEM DESCRIPTION

A. System shall be of the Grid-Tied type, connected to the electrical utility via utility meters. System shall be monitored through the control system of the warehouses. The system shall have the following components:

1. PV modules.
2. Array frame.
3. DC String Combiner and Monitoring Boxes
4. Inverters.
5. Mounting structure.
6. Monitoring system.
7. Pyranometers.
8. Soiling sensors.

## 2.3 PV MODULES

A. PV modules shall be Mono-Crystalline with the following characteristics:

1. Minimum efficiency of 22% at Standard Test Conditions (STC).
2. 120 cells with 5 busbars as a minimum.
3. Bifacial type, double glass with bifaciality factor of 70% as a minimum.
4. Framed.

B. PV modules shall comply with IEC standards.

C. PV modules nominal power rating shall have positive tolerance.

D. PV modules shall be suitable for operation at system voltage up to 1500V DC.

E. PV modules shall have application class A and safety class II to IEC 61730.

F. PV modules shall be Fire Class (C) as a minimum, tested in accordance with IEC 61730 and ANSI/UL 790.

G. Modules shall be free of potentially induced discharge (PID) tested in accordance with IEC 62804.

H. Modules shall be factory pre-wired with junction boxes, bypass diodes, output cables and connectors.

I. Modules shall be resistant to blowing sand and dust when tested in accordance with IEC 60068-2-68.

J. PV modules shall be suitable for operation under environmental condition type AB8 to IEC 60364-5-51.

K. Modules shall be corrosion resistant against ammonia and salt mist when tested in accordance with IEC 62716 and IEC 61701.

L. PV modules shall be factory assembled before shipment or provided in subassemblies, provided that reassembly does not involve any action that might affect compliance with IEC 61730.

M. Modules shall be constructed in a way that guarantees ground continuity after installation.

N. All parts shall be prevented from loosening or turning that may cause any risk. Necessary locking devices shall be provided for any adjustable or movable structural part to reduce the possibility of unintentional movement that may entail any risk.

O. Encapsulation: The encapsulant shall fill all spaces inside the module and shall adhere to the front and back glass. The encapsulant should be stable at elevated temperature and high UV exposure.

P. Polymers used as an enclosure to live parts or supporting live parts or as an outer surface or as a barrier shall comply with operational category classification as required by IEC 61730-1.

Q. All structural glazing materials used as superstrates or substrates in modules construction shall comply with safety glazing requirements to ANSI Z97.1.

R. Glass Cover: Anti-reflective tempered glass to be used as the protective shield for the active surface area of the module and to maintain resistance against impacts and thermal shocks.

S. Front glass shall be coated with anti-reflective coating with high light transmittance and anti-soiling coating to act as a dust control material to minimize the soiling losses as per ACUD requirements. Coating shall be factory-applied. Contractor shall submit supporting manufacturer’s data and test reports performed by an independent testing laboratory to verify the coating performance.

T. Internal wiring shall have 90 deg. C insulation as a minimum and shall not be exposed to direct sunlight unless its insulation is rated as sunlight resistant.

U. Modules shall be provided with wiring terminals suitable to accommodate the current carrying conductors of the load.

V. Field wiring shall be rated as sunlight resistant.

W. Field wiring terminals shall comply with IEC 61730 requirements.

X. The module frame shall be made of corrosion resistant material electrically compatible with the structural material used for mounting the modules.

Y. The back of the module shall be sealed with a high quality back sheet made of highly durable material, suitable for harsh environments, high humidity, UV exposure and high salinity conditions. Contractor shall submit supporting manufacturer's data and test reports performed by an independent testing laboratory to verify the durability of back sheet material.

Z. PV arrays shall be accessible for inspection, maintenance or repairs without necessitating the dismantling of structural parts, cupboards, benches or the like.

AA. PV connectors shall comply with IEC 62852. Connectors installed outdoor shall be enclosed by a material complying with the following requirements: UV resistant to IEC 60731-1, IP55 degree of protection to IEC 60529, pass the steel ball impact test to IEC 60512-5-1 and IEC 60512-5-2, and meet the requirements of accessibility test to IEC 61730-2. For connectors including grounding members, the grounding member shall be the first to make and the last to break contact. Connectors that can be separated without the use of a tool shall not have accessible conductive parts.

BB. Junction Box: Junction boxes shall comply with EN 50548 and shall have an IP 65 degree of protection to IEC 60529 as a minimum. Junction boxes shall be completely water tight and resistant to temperature and UV radiation. Junction boxes shall contain both the positive and negative output terminals. The junction boxes shall contain a small replaceable cover for easy access for replacement of the blocking diode and bypass diodes. The junction boxes shall be completely filled with a soft, clear, removable, self-healing, room temperature cure, dielectric potting gel leaving no air gaps.

CC. Each module shall be equipped with 3 bypass diodes as a minimum.

DD. Modules shall be suitable for operating temperature in the range of -40°C to +85°C.

EE. PV modules shall withstand the worst environmental conditions in terms of ambient temperature, wind load, snow load, hail diameter and speed. The Contractor shall submit certified environmental conditions substantiating the adopted figures.

FF. Modules power temperature coefficient shall not exceed -0.31%/$^{o}$C.

GG. Each PV Module shall be provided with a tag specifying following information

1. Name of manufacturer of Solar Modules and Solar Cells.
2. Unique serial number and Model number of the Module.
3. Exact date of manufacturing.

4. Country of Origin.
5. I-V Characteristics.
6. Peak Wattage, $I_{mpp}$, $V_{mpp}$.
7. Date and Year of Obtaining PV Module IEC qualification certificate.
8. Name of Test lab who issued certificate.

## 2.4 DC STRING COMBINER AND MONITORING BOXES

A. DC string combiner and monitoring boxes shall comply with IEC 61439.

B. DC String Combiner and Monitoring Boxes shall be suitable for system voltage up to 1500V DC.

C. DC String Combiner and Monitoring Boxes shall have class II insulation.

D. DC String Combiner and Monitoring Boxes shall be suitable and derated for outdoor installations in the site ambient conditions as specified in relevant specification sections.

E. DC String Combiner and Monitoring Boxes shall have IP 65 degree of protection as a minimum, UV resistant.

F. The DC String Combiner and Monitoring Boxes shall comply with be IEC 61000-6-1 and IEC 61000-6-3 for immunity and emission of EMC.

G. DC String Combiner and Monitoring Boxes shall be provided with the following as a minimum:

1. Main load-break switch disconnector.
2. Over current protection and disconnecting means via withdrawable gPV fuses to IEC 60269-6 to protect both polarities of each string.
3. Surge protective devices.
4. Arc fault detectors complying with UL1699B or IEC 63027.
5. Reverse current protection via blocking diodes, for each string.

    a. Blocking diodes shall be Schottky type with voltage drop not exceeding 0.4V at maximum array current.
    b. Diodes voltage and current rating shall be determined in accordance with IEC 62548.
    c. No live parts shall be exposed, all DC String Combiner and Monitoring Boxes shall have a shield over live components.
    d. Blocking diodes shall be protected against degradation due to the site environmental conditions.

6. Monitoring and control module to remotely monitor the following as a minimum:

    a. String DC input currents and array voltages with an error tolerance less than ±1%.
    b. Overcurrent and Overvoltage status.

c. Status of main switch disconnector.
d. Ambient parameters and internal temperature inside the DC combiner box.
e. Surge Protection Status.

7. RS485 Communications protocol.

H. PV string combiner and monitoring boxes shall be accessible for inspection, maintenance or repairs without necessitating the dismantling of structural parts, cupboards, benches or the like.

I. DC String Combiner and Monitoring Boxes shall be suitable for mounting as floor standing on support and as fixed to wall.

## 2.5 SMART INVERTER

A. Inverters shall be of the smart type and shall comply with IEC 62109 and IEC 62477.

B. Inverters shall be grid-tie type, central type with minimum of one independent Maximum power point tracking inputs.

C. Inverters output shall have a nominal AC voltage and frequency ranges conforming to local grid standards.

D. Inverters shall be suitable indoor installations and de-rated at the site worst ambient conditions as specified in in relevant specification sections.

E. Inverters shall have protection class I to IEC 62477-1 and overvoltage category III to IEC 60664-1.

F. Inverters shall have surge protection on both its DC input and its AC output.

G. Inverters' total harmonic distortion current shall not exceed 3% as per IEC 61000-3.

H. Inverters efficiency shall not be less than 98% for weighted European efficiency when tested in accordance with EN 50530.

I. Inverters shall have a maximum noise emission of 55 db(A).

J. Inverters shall be transformer-less type.

K. Inverters shall inject zero back feed current into the PV array under fault conditions.

L. Inverters shall be provided with all necessary protection and communication functions / devices including but not limited to the following along with all additional grid management functions as required by Authorities:

1. Power reduction.

2. Anti-islanding and grid monitoring functions.
3. Reactive power management and dynamic grid support.
4. Low voltage ride through.
5. Overcurrent protection on DC input side.

6. DC disconnection device.
7. Load-break switch disconnector (or circuit breaker) on AC side.
8. Ground fault monitoring.
9. Array earth insulation resistance monitoring device/function, tested in accordance with IEC 61557-8.
10. Metering for current, voltage and power at DC side with an error tolerance less than ±1%.
11. Metering for current, voltage, power and power factor at AC side shall be Class 1 with an error tolerance less than ±1%.
12. Adjustable output power factor to meet the local Authorities' requirements.
13. Communication interface with the PV monitoring and control system.
14. RS485 Communications protocol.
15. LED display screen to display system parameters.

16. Built-in cellular connectivity as per ACUD requirements.

M. Inverters' shall be air or water cooled, as per manufacturer's recommendations. Inverters shall be provided with an enclosure ensuring that the minimum degree of protection to IEC 60529 is IP 65 for outdoor installations and IP 54 for indoor installations.

## 2.6 MOUNTING STRUCTURES

A. Type: Roof mounted, Fixed with suitable tilt angles as per site conditions in accordance with vendor requirements.

B. Mounting structure shall be made of galvanized steel in accordance with ISO 1461 or aluminum.

C. Mounting structure thickness, joints, welds, bolts, foundation, etc. shall be designed to withstand gust wind velocity of 160 km/hr blowing in the most unfavorable direction at a height 10 m above ground level.

D. Mounting structure design shall comply with the PV modules manufacturer's recommendations. The Contractor is responsible for coordination between both suppliers.

## 2.7 CLEANING SYSTEM

A. Type: Manual cleaning system shall be provided.

B. Cleaning system shall support both wet and dry cleaning.

C. Contractor shall ensure compatibility between the cleaning system and the PV panels such that cleaning will not result in any negative impact on the PV panels glass or any microcracks.

D. Provide proper water supply for the cleaning process. Ensure that quality of water meets the PV panels manufacturer's recommendations.

## 2.8 MONITORING AND CONTROL SYSTEM FOR PV PLANT

A. PV Plant monitoring and control system shall comply with IEC 61724.

B. The plant shall be provided with a complete photovoltaic monitoring & control system which shall include the following:

1. Performance meters.
2. Environmental sensors.
3. Module's temperature sensors.
4. Current transducers.
5. Data loggers.
6. All necessary devices to achieve the required functions.

C. The system shall be a remote, real-time monitoring system capable of recording and transmitting real time and historical solar performance data.

D. The monitoring and control system shall achieve the following:

1. Control the plant parameters.
2. Monitor and verify the performance of each section of the plant against the design expected performance.
3. Initiate alarms in case of any equipment failure, fault and / or under performance.
4. The system shall provide real time displays.

E. The system shall control the following parameters as a minimum:

1. Adjust the plant performance to match the current grid set points at point of interconnection.
2. Active/Reactive Power management.
3. Power Curtailment and ramp rate control.
4. Dynamic grid support.

F. The system shall provide real time measurements for all parameters specified in IEC 61724 including but not limited to the following:

1. Meteorology:

a. Total irradiance in the plane of the array.
b. Total horizontal irradiance.

c. Ambient air temperature in a radiation shield.
d. Wind speed.

2. Photovoltaic array:

a. Output voltage.
b. Output current.
c. Output power.
d. Module temperature.

3. Utility Grid:

a. Utility voltage.
b. Current to utility grid.
c. Current from utility grid.
d. Power to utility grid.
e. Power from utility grid.

4. Inverter:

a. DC current and voltage at each MPPT input to the inverter.
b. Frequency at the inverter output.
c. Voltage and current at inverter output.
d. Active power at the inverter output.
e. Reactive power at the inverter output.
f. Accumulated active energy yield.
g. Power Factor.
h. Internal temperature.

5. DC Combiner Boxes:

a. DC current and voltage on each string and sub-array which are connected to DC combiner boxes.
b. Internal temperature.

6. Reactive power compensation equipment.
7. Injected active and reactive energy.
8. Consumed active and reactive energy.
9. Number of operating hours.

G. The system shall be able to obtain the following status / alarms:

1. Overcurrent status in DC combiner boxes.
2. Overvoltage status in DC combiner boxes.
3. Status of main disconnecting switch in DC combiner boxes.
4. Overvoltage status at inverters input & output sides.
5. Status of disconnecting switches at inverters DC side.
6. Status of disconnecting switches at inverters AC side.
7. General alarms and warnings.

H. The system shall have the following functionalities as a minimum:

1. Remote access for inverters monitoring.
2. Analysis and calculation of the Performance Ratio, energy yield and availability (grid and plant) on both long term and short term basis.
3. Real-time monitoring of the plant output and comparison against the anticipated performance or historical data.
4. Analysis and detection of equipment underperformance via comparison against historical data or similar equipment within the plant.
5. Remote notification to the operator in case of faults (via Email, SMS or similar).
6. Interface with the BMS system.

I. The system shall be provided with meteorological stations suitably located within the roof / plant; each meteorological station shall comprise the following components as a minimum:

1. Two secondary standard pyranometers installed in the plane of array with an error tolerance less than ±2%.
2. Two secondary standard pyranometers installed in the horizontal plane with an error tolerance less than ±2%.
3. Sufficient number of PV module temperature sensors (PT1000) installed at various locations which shall be representative of the array conditions. Such sensors shall be auto adhesive type and located at the back surface of the modules. Module locations shall be determined as per method A in IEC 61829. The PT sensors error tolerance shall be less than ±1°C. The cell temperature in front of the sensor shall not be substantially affected by the sensor's presence.
4. One ambient temperature sensor to measure ambient temperature with an error tolerance less than ±1°C.
5. Two reference cells installed at the plane of array.
6. One anemometer to measure wind speed.

J. Each meteorological station shall continuously transmit (at adjustable rate down to 1 second) the below parameters to the Plant monitoring & control system as a minimum:

1. Irradiance data from all installed pyranometers and reference cells.
2. Module temperature.
3. Ambient temperature.
4. Wind speed.

K. Miscellaneous Requirements:

1. All sensors shall have valid calibration certificates and shall be submitted to the Employer.
2. The PV monitoring & control system shall be compatible with the Plant system components. Both inverters and combiner boxes manufacturers along with the system supplier shall confirm compatibility among various components and the monitoring system.
3. The system supplier shall provide 24/7 technical support.

4. The sampling interval shall not exceed 1 minute for parameters which vary directly with irradiance and shall be in the range of 1-10 minutes otherwise.
5. A monitoring log shall be kept for all unusual events, component changes, failures, faults or accidents. Also, other comments which would be useful in interpreting and evaluating the data shall also be noted.
6. All system maintenance events shall be explicitly documented.

L. The supplier shall provide all necessary hardware and software that are required for a seamless interface to an integration platform or Cloud based solution, including Digital Twins, without the need for any additional licenses. All cybersecurity requirements shall apply to the communication interface provisions between the system and the integration platform / Digital Twin. The system shall be interfaced with the Digital Twin system through any of the following protocols: Modbus TCP/IP, BACnet/IP, OPC or MQTT. Coordinate with Digital Twin system supplier for the final list of supported protocols. Provide any necessary gateways to ensure proper integration without the need for any additional hardware, drivers or protocol converters by the Digital Twin supplier. Bidirectional communications with the integration platform / Digital Twin shall be available for the transfer of data, as requested by the Employer.

## PART 3 - EXECUTION

### 3.1 EXAMINATION

A. Examine substrate areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Do not begin installation until mounting surfaces have been properly prepared.

C. Examine modules and array frame before installation. Reject modules and arrays that are wet, moisture damaged, or mold damaged.

D. Examine roofs, supports, and supporting structures for suitable conditions where PV system will be installed.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.2 PREPARATION

A. Surface Preparation: Prepare surface in accordance with manufacturer's written recommendations and coordinate with relevant Sections of the specification.

### 3.3 INSTALLATION

A. Coordinate installation of components in accordance with manufacturer's installation instructions.

B. Coordinate solar electric module work with work of other trades for proper time and sequence to avoid construction delays.

C. Accurately fit, align, securely fasten and install free from distortion or defects.

## 3.4 FIELD QUALITY CONTROL

A. Equipment: Inspect equipment upon delivery to site and report any damage to the Engineer.

B. Equipment: Check equipment characteristics including ratings, types, sizes, fuses and switches and report any deviation from specified material to the Engineer.

C. Manufacturer Services: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

1. Have manufacturer review work involved in handling, installation/application, protection and cleaning of products, and submit written reports in acceptable format to verify compliance of work with Contract.
2. Manufacturer's Field Services: Provide manufacturer's field services, consisting of product use recommendations and periodic site visits, for product installation inspection in accordance with manufacturer's instructions.
3. Perform tests and inspections with the assistance of a factory-authorized service representative.
4. Schedule site visits to review work at stages listed:

    a. After delivery and storage of products, and when preparatory work on which work of this Section depends is complete, but before installation begins.
    b. Twice during progress of work at 25% and 60% completion.
    c. Upon completion of work and after cleaning is carried out.

5. Obtain reports within three days of review and submit immediately to the Engineer.

D. Tests: Tests shall be certified by manufacturer’s authorized representatives.

E. PV module will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

G. Test installation for reflectivity to ensure no-glare is transmitted to pilots and air traffic control towers at all times of the day.

## 3.5 IDENTIFICATION

A. Identify equipment and components according to Division 26 Section "Basic Electrical Materials and Methods" and comply with EN 50380.

B. Modules rated for maximum system voltage exceeding 50 V shall have a highly visible warning label regarding shock hazard and it shall be applied near module's connection means.

C. All system components which may be energized during daylight shall be labelled as required in local codes and regulations, in addition to a "Live during Daylight" label.

D. Labelling and identification of all conductors, equipment and disconnection devices shall comply with the following Standards:

1. IEC 60364-7-712.
2. IEC TS 62738.
3. IEC 62548.
4. IEC 62446-1.

## 3.6 SYSTEM STARTUP

A. System's Testing and Commissioning shall be in accordance with the following:

1. IEC 62446-1 requirements.
2. IEC 60364-6 requirements.
3. Manufacturers' testing procedure.

In addition to the above, testing and commissioning procedure shall cover but not necessarily limited to the tests specified in the Specifications.

B. Sequence of tests shall be as per the Standards' requirements and manufacturers' recommendations.

C. Field Tests: Perform the following tests:

1. Earthing continuity: Test electrical earthing continuity for all DC side circuits. Also, verify connection to the main earthing terminals.
2. Polarity test: Verify polarity of all DC cables and verify that all cables are correctly identified and connected into the system components.
3. Combiner box test: Ensure all strings interconnected at the combiner box are connected correctly in terms of polarity. Tests shall be performed using voltmeter connected to a common positive pole to ensure that any error in polarity will result in a significant voltage reading.
4. String open circuit voltage test: Measure open circuit voltage of each PV string. Compare measured with expected values and ensure that the readings are within 5% of the expected value.
5. String circuit current test: Correct operational characteristics of the system and proper wiring with no faults shall be verified through PV string short circuit current test conducted by proper equipment. This test shall not be taken as a measure of module / array performance.

6. Functional tests: Perform the following:

    a. Switchgear and other control apparatus shall be tested to ensure correct operation and that they are properly mounted and connected.
    b. All inverters shall be tested to ensure correct operation. Testing shall be as per the manufacturer's requirements and covering the following as a minimum:

        1) Cable connections.
        2) Voltage and current input and output waveforms.
        3) Start-up and shut-down tests.

7. PV array insulation resistance: measure insulation resistance of all PV arrays or a group of strings not exceeding 10 kWp by applying 1000 V DC. Comply with IEC 62446-1 for test voltage and minimum insulation resistance.

8. String I-V curve measurement: test the I-V curve for each string to obtain the following information as a minimum:

    a. String open circuit voltage (Voc) and short circuit current (Isc).
    b. Max power voltage (Vmpp), current (Impp), and max power (Pmax).
    c. Measurement of array performance.
    d. Measurement of module / string fill factor.
    e. Identification of module / array defects or shading issues.

    IV curve testing shall be associated with irradiance and cell temperature measurements.

9. Infrared camera scanning: Perform an infrared scan of the whole installation during normal operation and at irradiance exceeding 600 $W/m^2$.

    a. Use an infrared camera designed to measure temperature and detect significant deviations from normal values. Provide documentation of device calibration.
    b. Document areas of temperature extremes by clearly marking their location on the components or on the array / string layout drawings.
    c. Investigate each thermal anomaly to determine the cause(s) of such anomalies.
    d. Prepare a certified report identifying the checked installation and describing results of scanning. Include notation of deficiencies detected, remedial action taken and scanning observations after remedial action.

10. Blocking diode test: Inspect all diodes to ensure that they are connected in correct polarity and that there is no evidence of overheating or carbonization. Measure the voltage across the blocking diode.

D. Test reports shall comply with IEC 62446 requirements.

E. Energy performance test: Perform energy performance test after energization of the Plant by conducting trial operation for 10 days. Calculate the actual achieved performance ratio and compare it against the expected performance ratio for the month of the testing as per the simulation results. Negative deviation shall not exceed 0.5%.

F. Harmonic measurements: Measure the harmonics in the network and ensure compliance with requirements for each individual order and for the total harmonic distortion.

G. Verify proper performance of energy meter in accordance with requirements.

H. Test and verify performance of the remote monitoring system.

I. Check alarms and messages to ensure proper and safe operation.

J. Any tests requested by manufacturers shall be performed by the Contractor

K. Manufacturer's instructions shall be followed under all circumstances. Carry out and record measurement and tests recommended by the manufacturer.

L. List actions applicable to operational systems and equipment startup.

## 3.7 ADJUSTING

A. Adjust components and systems for correct function and operation in accordance with manufacturer's written instructions.

B. Set field-adjustable switches and circuit breaker trip ranges as required.

## 3.8 CLEANING

A. Cleanup shall be performed in accordance with the manufacturer’s recommendations.

B. Cleaning strategy shall be developed covering the cleaning method and cleaning frequency while considering the site’s environmental condition and in order to ensure that the maximum annual loss due to soiling doesn’t exceed 2%.

C. Upon completion, remove surplus materials, rubbish, tools and equipment.

## 3.9 PROTECTION

A. Protect installed product from damage during construction in accordance with the relevant section of the specification.

B. Repair damage to adjacent materials caused by solar electric module installation.

## 3.10 DEMONSTRATION AND TRAINING

A. Train Employer's maintenance personnel to adjust, operate, and maintain the system installation. The training shall be conducted by each system component's supplier. Provide written troubleshooting guidelines and maintenance / cleaning procedures. Refer to Division 01 Sections related to Demonstration and Training.

# 23 LIGHTING INSTALLATIONS

## 231 GENERAL LIGHTING INSTALLATIONS

### 231: A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: complete indoor and outdoor lighting installations including fixtures, control gear, mounting provisions, accessories and connection to circuit wiring and to corresponding lighting control equipment.

A201 FIXTURE DESIGN AND STANDARDS: the Specification and the Drawings are a guide to the selection of lighting characteristics and lighting fixtures, giving general features of construction, materials, method of installation and conditions of operation. Unless otherwise specified, fixtures are to be manufacturer's standard series, designed and manufactured for the purpose and application required, generally in accordance with the Schedule of Lighting Fixtures and complying with IEC 60598 and CISPR 15.

A251 DESIGN LAYOUT: fixture layout has been determined from photometric data of specified fixtures to achieve desired level and uniformity of illumination. Reflected ceiling plans are to be checked to ensure exact positions of fixtures with respect to structural members, ducts, pipes, other installations and ceiling panels/tiles, where required. Certain fixtures are shown in provisional positions, pending preparation of final equipment layout drawings. Such fixtures are to be located in coordination with final equipment layout so that illumination is as intended by the design.

A301 EQUIPMENT DATA: submit data for approval including, but not limited to, the following:

Detailed literature on each fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles

Details of changes to standard fixtures for adaptation to condition of installation and to the Specification

Photometric data for lighting calculations including polar light distribution curves, coefficient of utilization, glare classification, efficiency, depreciation factors etc.

Dimensions of fixtures

Certified results of independent laboratory tests for fixtures and lamps for electrical ratings and photometric data

For LEDs: Photometric test reports from accredited manufacturer's laboratories shall be submitted verifying the luminaire photometric characteristic; the testing shall conform to LM-79-08 or similar and approved international equivalent standard. Report shall include laboratory name, report number, date, luminaire catalogue number, luminaire, light source specifications, etc…

Emergency lighting unit battery and charger

Photo biological risk assessment for LED fixtures

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Exact position of each fixture on reflected ceiling plans, with indication of ceiling features, structural members, ducts, pipes and other fittings, as applicable and pertinent to the installation

Installation details including suspension and mounting provisions

Purpose made fixtures or lighting assemblies with full details

Wiring details, circuit and panel board references, special lighting control arrangements etc.

A601 SAMPLES: submit fully equipped sample of each fixture type, modified if required, together with colour and texture samples of each fixture.

## PRODUCTS AND SYSTEMS

### 231: X COMPONENTS AND ACCESSORIES

### 231: X1 LIGHTING FIXTURE CONSTRUCTION - GENERAL

X105 GENERALLY: construction and wiring of fixtures are to comply with the Regulations and Standards. Fixtures are to be fabricated, assembled and wired entirely at factory. Manufacturer's name, factory inspection stamp and official quality label are to be fixed to each fixture supplied.

X110 LIGHTING FIXTURES (LUMINAIRES): to be manufacturer's standard, as given in Lighting Fixture Schedules shown on the Drawings, or equal.

X115 SHEET STEEL HOUSINGS: to be not less than 0.6 mm thick, and thicker when required by the Specification or the Standards.

X120 SHEET STEEL REFLECTORS: to be not less than 0.5 mm thick.

X125 ALUMINIUM REFLECTORS: to be not less than 0.7 mm thick, unless otherwise approved.

X130 FABRICATION: metalwork is to be mitred, welded and ground smooth without tool marks or burrs. Flat metal parts are to be stiffened by forming grooves and edges during fabrication. Metal parts are to have finish free from irregularities.

X135 RUST-PROOF FERROUS BASE: ferrous metal parts are to be bonderized (treated with corrosion resistant phosphate solution) and given an approved rust-inhibiting prime coat before application of final finish.

X140 FINISH FOR NON-REFLECTING METAL SURFACES: approved baked enamel paint. Paint colour on fixture frames and trims is to be as specified or as selected by the Engineer.

X145 FINISH FOR LIGHT REFLECTING SURFACES: white baked enamel paint having reflection factor not less than 85%. Mirror reflectors, where specified, are to be highly polished, anodized aluminium with reflection factors not less than 97%.

X150 MECHANICAL RESISTANCE OF FINISH: after finish has been applied on steel surfaces and cured, it is to withstand a 6 mm radius bend without showing signs of cracking, peeling or loosening from base metal.

X155 RESISTANCE OF FINISH TO ULTRA-VIOLET: finish is to withstand 72 hours exposure to an ultra-violet RS lamp placed 100 mm from surface without discolouring, hardening or warping, and is to retain the same reflection factor after exposure.

X160 HEAT RESISTANCE: finishes, wires and components inside fixtures are to be certified materials to resist the temperatures or other conditions encountered in the fixtures.

X165 WIRING INSIDE FIXTURES: to be not less than 1.5 mm2, and insulated for 240 V application. Insulation is to have acceptable characteristics to resist maximum temperatures inside fixtures. Wiring is to be terminated on screw type, fixed, insulating, terminal blocks.

X170 HINGES: fixtures with visible frames and hinged diffusers are to have concealed hinges and catches, and stainless steel retaining clips. Other alternative equally durable products may be submitted for approval.

X175 SUSPENSION ALIGNERS: to be provided for pendant fixtures for axial, vertical and horizontal alignment. Vertical adjustment is to be minimum 25 mm.

X180 RECESSED FIXTURES: to be constructed to fit into suspended ceilings without distorting fixture or ceiling. Plaster rings are to be provided for plaster or concrete ceilings.

X185 OUTDOOR FIXTURES: to be non-ferrous metal or specially moulded material for outdoor use.

X190 REMOVAL OF PARTS for maintenance is to be possible without removing fixture housing.

231: X3 LIGHT EMITTING DIODE (LED) LIGHTING FIXTURES - GENERAL

X310 LIGHT EMITTING DIODE shall be a solid state device embodying a p-n junction, emitting optical radiation when excited by an electric current. It shall be part of the LED module which is supplied as a light source. Output color consistency shall be guaranteed and have a Color Rendering Index (CRI) greater than 70 and 80 for exterior and interior lighting fixtures respectively measured in accordance with IES LM-79-08, unless otherwise indicated on drawings.

X315 LED luminaires shall comply with IEC 60598.

X320 LED luminaires' efficacy shall be as shown on Drawings or 75 lumen per watt whichever is more stringent.

X325 GUARANTEED RATED LIFE (L80B50) shall not be less than 50,000 hours and 35,000 hours at 25 deg. C and 35 deg. C respectively for interior lighting fixtures and 50,000 hours at 50 deg. C for exterior lighting fixtures, as per IES LM-80-08, Approved Method: Measuring Lumen Maintenance of LED Light Sources and IES TM-21-11, Projecting Long Term Maintenance of LED Light Sources.

X330 LUMINAIRES guaranteed lifetime shall cover all fixtures components including lamp, fixture and drivers.

X335 LED luminaires shall be suitable for 24/7 continuous operation at 50 deg. C with no negative effect on the luminaire life time and / or performance in terms of color temperature and lumen output.

X340 LEDs shall comply with Photo-biological Safety of lamps and lamp systems in accordance with the requirements of IEC 62471. Provide a test report to prove the fixture is classed as “Exempt” or “Risk Group 1”.

X345 Each luminaire type shall be binned within a three-step MacAdam Ellipse for indoor luminaires and five-step maximum for outdoor luminaires to ensure color consistency among luminaires, unless more stringent requirements are indicated on Drawings.

X350 EMI/RFI shall meet EN 55015 requirements.

X355 The maximum percentage of direct up-light from the outdoor luminaires shall be as CIE 126-1997.

X360 HOUSING, for non-linear luminaires, shall incorporate an adequate heat sink, the design of the heat sinks shall be such that there is a direct thermal path from the LED junctions to the atmosphere thus providing a thermal transfer effect throughout the life of the luminaire which ensures the overall fittings and the LEDs are kept relatively cool and any heat generated throughout the life of the strip at the specified ambient temperature doesn’t affect the guaranteed life time and / or luminaire performance.

X365 Electronic LED Drivers: high efficiency, high power factor, suitable for operation at the ambient conditions specified for the project. Driver shall have constant output current or constant output voltage over the whole wattage range independent of mains supply fluctuations as shown on drawings and sufficient for operating the number and wattage of LEDs connected. Guaranteed rated life of the driver shall be 50,000 hours as a minimum.

X370 LED drivers shall have electrical insulation between primary and secondary sides. Secondary cables from the driver to LED modules shall be provided by the LED supplier. Maximum length between driver and LED module shall be as per manufacturer’s recommendations.

X375 LED driver shall be protected against electric shock, accidental contact with live parts, short circuit, overload, over temperature where the output current is reduced if the temperature limit is exceeded.

X380 In case LED luminaire internal temperature monitoring is required then the LED driver shall be provided with the possibility to connect a temperature sensor to monitor the LED temperature and protect the LED modules against thermal damage.

X382 Dimmable driver, where required, shall be compatible with the dimming system used.

X385 Drivers shall be compatible with the lighting control system used such as; 1-10V, DALI, DMX, etc...

X390 LED driver shall be provided with constant light output function, where required on Drawings, in order to maintain the light output of the LED by increasing the LED driving current over the lifetime.

X395 LED driver shall comply with IEC 61347-1, IEC 61347-2-13 and IEC 62384 and shall meet the limits of main harmonic content as defined in IEC 61000-3-2 and comply with radio interference suppression limits defined in BS EN 55015 and immunity requirements of IEC 61547.

## 231:X7 FLOODLIGHTS

X705 TYPE: totally enclosed type, weather, dust and shock resistant, IP 64 of IEC 60529.

X710 HOUSING: high pressure die-cast aluminium alloy, closed on front by hinged framed protector highly resistant to thermal and mechanical shocks, and set in position by at least eight heavy duty stainless steel spring clamps with silicon sealing gasket. Enclosure is to be in accordance with IEC 598-2-5 , and is to be suitable for operation in an ambient temperature of 70 deg. C.

X715 REFLECTORS: high purity (over 99% reflectance) anodized aluminium, secured in precision aligned internal tracks to provide beam distribution required.

X720 CONNECTION BOX is to be located at rear of floodlight body with gland connections to accept 4 mm2 PVC/PVC three core cable. Lamp and control gear are to be mounted in two separate and isolated compartments.

X725 CONTROL GEAR: plug-in type, 220 V, 50 Hz, power factor compensated to at least 0.9 lagging. Ballasts and ignitors are to be type specially adapted for make of lamps selected. Ignitors are to be electronic thyristor type. Lamp is to be able to start with at least +/-10% line voltage, and with normal operation dips up to 20% for four seconds. Compensation is to ensure that there is no large increase in operating current during starting. Control gear losses are not to exceed 10%. Cables for internal wiring in control gear compartments are to be single core 2.5 mm2 copper conductors with high temperature insulation and sheath.

X730 FINISH: exposed metal parts of floodlights are to be painted with corrosion and heat resistant paint, resisting operating temperatures attained in direct sunlight while lamp is burning.

X735 MOUNTING: floodlights are to be located as shown on the Drawings and mounted on specially designed brackets to allow swivelling in any desired direction and locking firmly in final position. Protractor scale is to be provided for accurate setting.

X740 EARTHING TERMINALS: bolted earthing terminal is to be provided in each fitting.

## 231: Y FIELD AND INSTALLATION WORK

### 231:1 INSTALLATION

1051 GENERALLY: install fixtures level, aligned and parallel or square to building lines and at uniform heights as shown on the Drawings or as approved by the Engineer. Make final height adjustment after installation.

1101 FIXTURE SUPPORT: provide fixture and/or fixture outlet boxes with hangers, brackets and flanged bolted fittings, as necessary, to support weight of fixture. Submit details of hangers etc. and method of fastening for approval. Rigidly secure fixtures mounted on outlet boxes to fixture studs. Install hooks or extension pieces, when required, for proper installation. Provide one point of support in addition to the outlet box fixture stud for individually mounted fixtures longer than 600 mm.

1251 STEM HANGERS: provide two stem hangers for individually mounted pendant fixtures. Stems are to have suspension aligners and are to be of suitable length for suspending fixtures at required height.

1301 SUSPENDED CEILINGS: if ceiling construction is unable to support weight of fixtures without strain or deformation, suspend fixtures directly from building structure.

1351 SOLID CEILINGS: coordinate dimensions of recesses in ceilings with exact fixture dimensions and structural elements.

1401 CONTINUOUS ROWS: arrange fixtures so that individual fixtures can be removed without dismantling remaining fixtures. Provide minimum spacing between fixtures.

1451 COVER PLATES: install cover plates over fixture outlet box or opening in ceiling or structure when left unused.

1501 FLUSH RECESSED FIXTURES: install to completely eliminate light leakage within fixture and between fixture and adjacent finished surface.

1551 VENTILATION: keep ventilation channels free after fixture is installed, if required by the design of the fixture.

1601 EARTH metal frames of as described in Section 219 of the Specification.

1651 TIGHTNESS: ensure that enclosed fixtures are reasonably insect/dust tight when installed, and completely weather- proof for installations subject to weather conditions.

1751 LAMPS FOR PERMANENT INSTALLATION: place new lamps in fixtures immediately prior to hand-over and when instructed by the Engineer. Lamps used for temporary service are not to be used for final lamping of fixtures.

1851 FIXTURES: Set level, plumb, and square with ceiling and walls, and secure according to manufacturer's written instructions and approved submittal materials. Install lamps in each fixture.

## 231:2 INSPECTION AND TESTS ON SITE

2051 VISUAL INSPECTION: check neatness of installation, uniformity of equipment and nameplates etc. Replace damaged fixtures and components.

2101 ILLUMINATION MEASUREMENTS: to be taken at selected locations, to determine level and uniformity.

2151 OPERATION: check lighting installations for operation including control and regulation equipment.

2201 ELECTRICAL DATA: measure power factor, current and voltage at start for installations with discharge lamps.

2301 TESTS: are to include the following:

Verify normal operation of each fixture after installation.

Emergency Lighting: Interrupt electrical supply to demonstrate proper operation.

Verify normal transfer to battery source and retransfer to normal.

Report results in writing.

2401 MALFUNCTIONING FIXTURES AND COMPONENTS: replace or repair, then retest. Repeat procedure until units operate properly.

2501 CLEANING AND ADJUSTING: clean fixtures internally and externally after installation. Adjust amiable fixtures to provide required light intensities.

# 232 OUTDOOR AREA LIGHTING

## 232:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: outdoor area and access road lighting including luminaires, columns, related power distribution and control, protective earthing and related builder's work including column foundations, cable pits, cable trenches and ductwork.

A201 STANDARDS: luminaires generally are to comply with IEC 60598 and the applicable C.I.S.P.R. recommendations. Manufacturer is to verify compliance with these standards and the applicable local regulations and design standards.

A251 TECHNICAL REQUIREMENTS: minor deviations from the Drawings may be considered for improvement in construction details, but no changes are to be made without the written approval of the Engineer.

A261 AMBIENT CONDITIONS: unless otherwise specified, equipment is to be designed and derated for continuous and trouble-free service at 50 deg. C ambient temperature and 100% relative humidity, with temperature reaching 70 deg. C in direct sunlight and with high content of ultra-violet rays. Equipment is to withstand full load operation whilst exposed to sun.

A301 EQUIPMENT DATA: submit complete data for approval including, but not limited to, the following:

detailed literature, in English, for each type of luminaire or fixture, lamp and control gear including manufacturer's name, catalogue number, rating, material specification, overall dimensions, operating characteristics and principles, and any modification to a standard product if applicable,

detailed specification and drawings for each column type including shape, base/mounting flanges, bolts, nuts etc, cross-sections, design criteria and calculations, brackets, finishes, provisions for cabling, cut-out or circuit-breaker, etc.

photometric data for lighting calculations including polar curves, coefficients of utilization, efficiency and depreciation factors.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

layout of equipment in exact positions with mounting and construction details, concrete foundation dimensions and reinforcement, routing and sections of duct-banks and trenches, backfill and packing material, earthing rods, etc.

cabling and wiring diagrams, single line drawings, loads, phase distribution, protection and control, earthing and the like,

calculations of illumination levels and glare, based on CIE methods.

A601 SAMPLES: submit fully equipped sample of luminaire or other materials or components if required by the Engineer.

A701 SPARE PARTS: provide items necessary for maintenance, and up to 5% (or nearest whole unit) of installed quantities of each type of lamp, control gear, fuses, luminaire covers, special bolts or nuts, lamp-holders and the like which are subject to burning, breakage or failure.

PRODUCTS AND MATERIALS

232:H LIGHTING COLUMNS

H105 CONSTRUCTION: columns are to be circular section, tapered, formed sheet steel, electrically welded, and of height specified. Columns up to 12 m height are to be one piece section. Columns are to have minimum wall thickness of 3 mm at base. Sheet steel is to have minimum rupturing resistance of 37 kg/mm2 and minimum yield strength of 24 kg/mm2.

H205 TOP OF COLUMN is to be designed to receive single or double arm brackets or other arrangement required, to support number of luminaires shown on the Drawings. Bracket arrangement is to be designed to ensure that failure, due to wind induced oscillations, does not occur and that rotation from desired alignment is not possible.

H255 COLUMN DESIGN: column cross-section, thickness of steel, joints, welds, bolts etc. are to be designed to withstand gust wind velocity of 160 km/hr blowing in the most unfavorable direction at a height 10 m above ground level, with column fully equipped. Fatigue of steel is in no case to exceed half elasticity limit, taking into account dynamic stresses due to vibrations. Steel flange plate, of adequate thickness, is to be solidly welded onto lower edge of column as shown on the Drawings, and is to have specified number of

holes for holding down bolts together with central cable access hole not less than 150 mm diameter.

H305 ACCESS DOOR of weatherproof construction is to be positioned at column base and is to be suitably sized to insert and service the supply cable terminations and protective device. Door is to be flush fitting with retaining mechanism and positive locking arrangement with removable hexagonal key. Column is to be reinforced at door opening. Opposite each door, a non-hygroscopic baseboard of suitable size to accept appropriate equipment is to be fixed to inside of column by purpose-made brackets. Stainless steel earthing stud with washers and nuts is to be welded inside the column near the access door.

H405 FINISH: welds are to be smooth with spatter removed, inside and outside surfaces of column are to be cleaned by pickling or blasting and are to be free of grease. Steel components of columns are to be hot-dip galvanized after fabrication. Minimum thickness of zinc coating is to be 500 g/m2 on both inside and outside surfaces of column. Galvanizing is to be to BS EN ISO 1461. Any damage to galvanizing is to be rectified during erection by wire brushing affected area and treating with approved rust converter to the satisfaction of the Engineer. Flange plate and inside and outside of column base are to be coated with heavy bitumen paint prior to erection.

H505 PROTECTION AND WIRING: columns with one or two luminaires are to be connected over one phase and neutral. Columns with three or more luminaires are to be connected over 3 phases and neutral, unless otherwise shown on the Drawings. Bolted terminals and cable lugs are to be provided with 3 phases and neutral terminals, for incoming and outgoing 3 phase 4 wire cable, and of the sizes shown on Drawings. One circuit breaker, single pole 15 A is to be provided for each phase leading to a luminaire. Circuit breakers are to be compensated and rated for 50 deg. C ambient with interrupting capacity of at least 9 kA, and are to be mounted in weatherproof enclosure at baseboard. Wiring is to be PVC insulated 3 core or 4 core 85 deg. C conductor temperature. Cable is to be at least 4 mm2 copper conductor.

## 232:H8 HIGH MASTS

H810 Masts shall be of multi-sided or circular section. Sections shall be joined by means of pressure overlapping or slip joints having a minimum length of 1.5 times the diameter of the joint. Site welding is not permitted.

H815 WALLS of the masts shall have a minimum thickness of 4 mm and a minimum rupturing resistance of 510 MN/sq.m and minimum yield strength of 330 MN/sq.m. The maximum deflection at the top of the mast shall not exceed 2.5% of the mast height with the wind speed detailed.

H817 Adequate protection against saline environment is to be provided. Contractor to support his proposal with related documents for Engineer approval.

H820 Contractor is to submit detailed calculations and supporting data to verify that the mast meets the above requirements.

H825 A steel flange of adequate thickness and free from laminations shall be welded to the base of the mast. In addition, supplementary gussets shall be provided, if deemed necessary.

H830 An access door shall be provided in the base of the mast of adequate dimensions to permit clear access to the back plate installed for mounting the junction box, circuit breakers, winch, etc. The door shall be completely weatherproof and fitted with a heavy duty lock. Door area shall have appropriate reinforcement. A stainless steel earthing bolt shall be welded inside the mast, near the access door, and shall be provided with stainless steel washers, nuts and lock nuts.

H835 The luminaire ring shall be constructed of hot dipped galvanized steel fitted with the appropriate number of luminaires. The ring shall be designed to provide appropriate distribution of lighting. The head frame shall be covered by a shaped, protective and aesthetic skirt designed to give a coordinated appearance between the ring and the head frame.

H840 As masts are provided with mobile ring, rollers with a centering mechanism shall be provided in order to ensure perfect alignment of the ring in all directions while raising or lowering the mast. Rollers shall be made of adequate material. All shafts and washers shall be made from stainless steel. A weatherproof wiring chamber shall be provided and installed on the luminaire ring and shall be equipped with the proper terminal blocks, neutral bar, earthing connections and including facilities on the ring to allow testing of luminaires while in the lowered position.

H850 Cables installed in the luminaire ring and connecting each luminaire to the wiring chamber shall be factory pre-wired.

H860 Head frames shall be hot dipped galvanized attached to the mast by means of a steel slip-fitter and secured by at least 4 stainless steel set screws. They shall house the required number of ropes and pulleys and associated accessories for operating the luminaire ring.

H865 Pulleys shall be of non-corrosive material grooved to suit the steel rope.

H870 Luminaire ring shall be supported by 3 steel ropes coupled to 2 steel ropes from the double drum winch. A separation of steel ropes during lowering and raising is to be provided. Flexible stainless steel stranded wire ropes with a factor of safety, not less than 5 times the safe working load of the winch shall support the ring assembly. A steadying system shall keep the ring in the correct top position avoiding any rotation.

H875 Luminaire ring shall be raised and lowered for installation and maintenance purposes by means of a winching system specially designed to be installed and removed through the access door at the mast base. Winching system shall have a lifting capacity of at least twice the weight of the luminaire ring assembly. Winching system shall employ double drums for safety.

H880 Winches shall operate using portable power tool incorporating an adjustable and lockable torque limiting device. Power tool shall be equipped with a remote control and adequate protection.

H885 Masts shall be equipped with lightning protection, aviation obstruction warning lights and earthing system.

## 232:H9 AVIATION OBSTRUCTION WARNING LIGHTS

H905 AVIATION OBSTRUCTION WARNING LIGHTS shall be provided for all fixed and movable structures as applicable under the ICAO annexe-14 and Department of Civil Aviation requirements. Aviation obstruction warning lights shall be certified in compliance to ICAO.

H910 AVIATION OBSTRUCTION WARNING LIGHTS shall be low-intensity, medium-intensity or high-intensity, depending on the criteria established by the ICAO Annex-14 and required by the Department of Civil Aviation.

H915 AVIATION OBSTRUCTION WARNING LIGHTS shall be twin type, with one lamp in normal operation and the other on stand-by, to be automatically switched on, in the event of failure of the normally operational lamp. Aviation obstruction warning light fixtures shall be metallic body with heat tempered glass cover.

H920 LAMP FAILURE and AUTO-CHANGE-OVER shall be monitored by a relay and audio-visual alarm annunciated at a local control panel and at a remote location where duly authorized technical/maintenance personnel are alerted to the alarm condition.

H925 ALARM CABLING shall be provided with protected containment to avoid damage.

H928 AVIATION OBSTRUCTION WARNING LIGHTS (low and medium intensity type) shall be provided with long life incandescent double filament lamps similar to “signal light” lamps. The lamps shall be suitable for locations where vibrations are experienced. They shall be rated for 240 V a.c., from reputed internationally recognized manufacturers and shall have a certified lamp life of at least 8,000 burning hours. The obstruction lights may also use LEDs a light source, with a manufacturer guarantee of 5 years. Aviation obstruction warning light covers shall be provided with a non-degradable chain connection to the body of the luminaire to avoid droppage during repair, maintenance, etc. and the glass dome covers/lenses shall be screw-on type.

H930 LOW INTENSITY FIXTURE shall have an effective intensity of not less than 10 candela, as certified by the manufacturer and medium intensity fixture shall have an effective intensity of not less than 1600 candela, as certified by the manufacturer. The photometric of the lighting fixtures shall be tested and certified by an internationally approved, independent testing laboratory.

H935 AVIATION OBSTRUCTION WARNING LIGHT fixtures shall be provided with internal components such as connection terminal blocks, gaskets, lamp holders, etc. which are not degraded by heat / U.V. Radiation / humidity, such as plastic, PVC, GRP, etc. Aviation obstruction warning lights shall be tested and certified for IP 65.

H940 POWER SUPPLY CABLING for the Aviation obstruction warning lights shall be armoured type and provided with protected containment to avoid damage. Joints are not permitted in the power supply cabling to the aviation obstruction warning lights.

H945 AVIATION OBSTRUCTION LIGHTING CIRCUITS shall be circuited in such a manner that failure of any one circuit shall not deprive the structure completely of obstruction lighting. Exception shall be permitted in specific cases where only a single fixture is feasible.

H950 AVIATION OBSTRUCTION WARNING LIGHTS shall be provided with flasher control units where requested by the Department of Civil Aviation. These units shall be provided with internal wiring using stranded copper conductor, double insulated, (105 °C) heat resistant type insulation and components certified for the intended duty and ambient conditions in metallic enclosure with IP 65 rating for outdoor or similar locations.

H955 JUNCTION BOXES/CONTROL PANELS/CONTROLLER BOXES used shall be metallic and rated IP 65. The controller/relay unit enclosures shall be provided with corrosion treatment and powder coated paint finish

H960 AVIATION OBSTRUCTION WARNING LIGHT system shall be suitable for 220V a.c +/- 10 percent at 50Hz and suitable to work in an ambient of +50 °C with a 100 % Relative Humidity and saline environment.

H965 All screws and bolts shall be provided with self-holding circlips, to prevent loss of screw/bolt after opening.

H970 AIRCRAFT OBSTRUCTION WARNING LIGHT FIXTURES may be provided with external paint finish. If provided, dark colours are not to be used and the paint material shall be certified for UV radiation withstand.

H975 FIXING HARDWARE shall be stainless steel.

H980 ALL AVIATION OBSTRUCTION WARNING LIGHTS and system shall be to specific approval of Department of Civil Aviation.

## 232:X LUMINAIRES AND FLOODLIGHTS

### 232:X1 ROAD LIGHTING LUMINAIRES

X105 CONSTRUCTION: totally enclosed, dust protected and splash proof, conforming to at least IP 54 of IEC 60529, shock resistant and specially designed to house required lamps, electrical gear and accessories. Body is to be corrosion resistant, extruded, pressure die-cast or fabricated aluminium alloy.

X110 FINISH: exposed metal parts of luminaires are to be factory finished, stove enamelled, with suitable corrosion resisting paint capable of resisting heat emitted by lamp during continuous operation, and under full sunlight conditions. Colour is to be agreed with the Engineer.

X115 MIRROR REFLECTORS: 99.5% purity, glazed and anodized aluminium or die-cast, super-purity aluminium vapour-deposited, and coated with transparent layer of silicon protection against wiping.

X120 LUMINAIRE PROTECTORS: heat and shock resistant glass, mounted into suitable frame assembly fixed to body by captive screws, and secured by extra safety clamps to allow replacement of protector and reflector. Ozone resistant ethylene propylene or approved equivalent rubber is to ensure sealing of the front glass.

X125 LAMP SOCKETS: high grade porcelain, mounted in support brackets with provision to adjust lamps vertically and axially. Lamp support and locking system are to grip and prevent lamp movement in operation.

X130 BALLAST AND CONTROL GEAR are to be mounted in luminaire in separate compartment isolated from lamp, and with encloterminal blocks fitted with quick-disconnect electrical leads. Where required, control gear is to be contained in the prewired box, having an enclosure of IP 65, and mounted on luminaire ring separately from luminaires. Control gear is to be plug in type for operation at &volt& V, a.c. single phase, &fr& Hz, ballast is to be specially selected for particular type of lamps used, and lamps are to be able to start with at teast +/-10% variation of nominal voltage and continue in normal operation with dips attaining 20% for four seconds. Control gear losses are not to exceed 10% of normal lamp wattage. RFI suppression device is to be provided. Power factor is to be compensated to at least 0.9 lagging.

X135 HRC FUSE CARTRIDGES, suitably rated and conforming with IEC 60269 , are to be provided, complete with base, for protection of the luminaire. Fuse is to be rated to withstand starting current and is to be preferably located in control gear enclosure.

X140 TERMINAL BLOCKS: suitable screw-tunnel type, clearly marked with arrangement to facilitate maintenance, quick replacement and easy disconnection of individual components.

X145 LAMPS: to be number and types shown on the Drawings and as described in Section 231 of the Specification.

## 232:X2 FLOODLIGHTS

X205 TYPE: totally enclosed type, weather, dust and shock resistant, IP 64 of IEC 60529.

X210 HOUSING: high pressure die-cast aluminium alloy, closed on front by hinged framed protector highly resistant to thermal and mechanical shocks, and set in position by at least eight heavy duty stainless steel spring clamps with silicon sealing gasket. Enclosure is to be in accordance with IEC 60598-2-5 , and is to be suitable for operation in an ambient temperature of 70 deg. C.

X215 REFLECTORS: high purity (over 99% reflectance) anodized aluminium, secured in precision aligned internal tracks to provide beam distribution required.

X220 CONNECTION BOX is to be located at rear of floodlight body with gland connections to accept 4 mm2 PVC/PVC three core cable. Lamp and control gear are to be mounted in two separate and isolated compartments.

X225 CONTROL GEAR: plug-in type, &volt& V, &fr& Hz, power factor compensated to at least 0.9 lagging. Ballasts and ignitors are to be type specially adapted for make of lamps selected. Ignitors are to be electronic thyristor type. Lamp is to be able to start with at least +/-10% line voltage, and with normal operation dips up to 20% for four seconds. Compensation is to ensure that there is no large increase in operating current during starting. Control gear losses are not to exceed 10%. Cables for internal wiring in control gear compartments are to be single core 2.5 mm2 copper conductors with high temperature insulation and sheath.

X230 FINISH: exposed metal parts of floodlights are to be painted with corrosion and heat resistant paint, resisting operating temperatures attained in direct sunlight while lamp is burning.

X235 MOUNTING: floodlights are to be located as shown on the Drawings and mounted on specially designed brackets to allow swivelling in any desired direction and locking firmly in final position. Protractor scale is to be provided for accurate setting.

X240 EARTHING TERMINALS: bolted earthing terminal is to be provided in each fitting.

## FIELD AND INSTALLATION WORK

### 232:1 INSTALLATION

1101 EQUIPMENT: install equipment to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made to accomplish this but no changes are to be made without the approval of the Engineer.

1201 COLUMN BASES: install columns on concrete bases as detailed on the Drawings. Before commencement of construction, ensure that bases are suitable for column installation. Holding down and plumb adjusting nuts, washers, locknuts or nyloc nuts are to be stainless steel or cadmium plated.

1251 COLUMNS: erect columns so that luminaires are located on a line parallel to theoretical profile of road. Alignment of columns, both horizontally and vertically, is to be secured to the satisfaction of the Engineer. Brackets are to be set at 90 degrees to longitudinal axis of road.

1301 MOUNTING ADJUSTMENTS: after demonstrating to the Engineer that specified lighting requirements have been met, carry out final setting and locking in position of the floodlights.

1401 CABLING, CONDUITS AND DUCTWORK: carry out in accordance with Sections 217 and 291 of the Specification. Cable ducts are to be directly buried except at crossings with other service work or roads.

1501 EARTHING: carry out in accordance with Section 219 of the Specification.

### 232:2 INSPECTION AND TESTS ON SITE

2101 VISUAL INSPECTION is to include inspection of condition of each piece of equipment, quality of workmanship, alignment, perpendicularity, labelling and the like, all in conformance with the Specification.

2201 INSULATION RESISTANCE AND CONTINUITY TESTS are to be carried out on each circuit and piece of equipment before energization, with circuit breakers in the open position and lamps not installed.

2251 OPERATIONAL TESTS are to be carried out on all circuit breakers and control gear, with lamps installed, including recording voltage at terminals of ballasts on final columns of each circuit and at distribution panel or the like.

2301 PERFORMANCE TESTS are to be carried out after 100 hours normal operation, and are to include measurement of lighting levels and uniformities on required illuminated surfaces.

2351 OTHER TESTS are to be carried out as required by the Engineer to verify conformity with the Specification.

2401 EARTHING RESISTANCE TESTS are to include measurement of earth electrode resistance at final points of circuits and continuity of protective conductors.

2501 RESULTS OF TESTS are to be recorded on site and signed by witnessing parties.

2551 TEST EQUIPMENT AND LABOUR: provide equipment and labour including instruments and complete provisions for carrying out tests.

# 24 WIRING DEVICES AND MISCELLANEOUS EQUIPMENT

## 241 WIRING DEVICES, DISCONNECTS AND LV DISTRIBUTION TRANSFORMERS

### 241:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: wiring devices, lighting switches, socket outlets, cord outlets, automatic and manual lighting control equipment, dimmers, outlet boxes and plates, dry- type LV transformers, disconnect switches etc.

A201 STANDARDS: components are to be standard manufactured items, uniform and modular, complying with one set of approved Standards.

A301 EQUIPMENT DATA: submit data for approval, including catalogues, detailed literature, manufacturer's name, catalogue number, rating, specification, overall dimensions and special features, as applicable for each item.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

exact indication of position of each item and outlet box and fitting on layout drawings, with box and equipment types and sizes

installation details of special items including LV transformers, isolating switches, fans etc.

wiring diagrams of special items.

A601 SAMPLES: submit samples of each type of device for approval, unless otherwise agreed in writing by the Engineer.

### PRODUCTS AND SYSTEMS

## 241:X FITTINGS

### 241:X1 OUTLET BOXES AND PLATES GENERALLY

X110 SURFACE OR RECESSED BOXES are to be suitable for type of related conduit or cable system. Shapes and sizes of boxes are to be of compatible standards as switches, socket outlets and lighting fixtures selected and of various types and mounting methods required.

X120 UNUSED OPENINGS in outlet boxes are to be closed with knock-out closers manufactured for the purpose.

X140 BLANK PLATES: blank plates are to be installed on outlet boxes on which no apparatus is installed or where apparatus installed does not have suitable cover for box. Blank plates for wall outlets are to be attached by a bridge with slots for horizontal and vertical adjustment.

X150 FLOOR OUTLETS AND PLATES are to be water-tight and impact resistant.

### 241:X2 METALLIC OUTLET BOXES

X210 RECESSED AND CONCEALED BOXES: galvanized pressed steel, with knock-outs for easy field installation. Special boxes are to be punched as required on Site.

X220 EXPOSED SURFACE MOUNTED BOXES: galvanized cast iron with threaded hubs.

X230 OUTDOOR SURFACE OR RECESSED BOXES: galvanized cast iron with threaded hubs and PVC gaskets to ensure water tightness and with stainless steel or non-ferrous, corrosion resistant screws.

X240 FLOOR BOXES - TYPE A: watertight, cast iron or cast metal alloy with corrosion resistant finish, adjustable mounting, standard duty, round or square, factory drilled and tapped for required conduit sizes, and with brass cover and flange with brushed finish free from markings other than required for mounting screws.

X245 FLOOR BOXES - TYPE B: non-standard size, flush floor mounted, cast metal alloy, with watertight neoprene gasketed and hinged cover, and with drilled and tapped conduit entries and adjustable mounting. Metal barriers are to separate services for power and low current.

X290 MANUFACTURERS: obtain metallic outlet boxes from same manufacturer as conduit or other approved, and to the satisfaction of the Engineer.

## 241:X3 MOULDED PLASTIC OUTLET BOXES

X310 TYPE: boxes and covers used with PVC conduit systems are to be heavy gauge pressure moulded plastic, minimum 2 mm thick, self extinguishing, with softening point not less than 85 deg. C. Boxes are to have provision for securely terminating conduits and are to be manufacturer's standard for required application.

X320 FITTINGS: boxes are to have brass inset threads to receive cover screws and for mounting devices or accessories, push-fit brass earth terminals, and steel insert clips to provide additional support for pendants or for heat conduction. Neoprene gaskets are to be provided for weatherproof installations.

## 241:X4 PLATES AND CORD-OUTLETS

X410 DESIGN: square, rectangular or round, designed to cover outlet box and to closely fit electrical device, and with polished chromium plated recessed head fixing screws. Combination plates are to be used for grouped outlets and devices.

X415 CORD EXTENSION PLATES are to have threaded cord grip bushings of same material and finish as plates.

X420 PLASTIC PLATES: heavy gauge, break resistant, pressure moulded plastic, white colour, for general use all over the building except for electrical and mechanical area.

X490 CABLE/CORD OUTLET is to be used for up to 45 A, 250 V rating for connection of power/control cable of fixed appliances. Plate is to have threaded cord grip to anchor cable securely to cover. Box is to include fixed terminal block and cable clamp for termination of cable/cord within.

## 241:X5 SWITCHES

X510 GENERALLY: quick-make, quick-break type with silver alloy contacts in arc resisting moulded base, with toggle, rocker or push-button as specified, for inductive or resistive loads up to full rated capacity, and arranged for side and/or back connection.

X515 TYPES: single, two-way or intermediate, single pole or double pole, as shown on the Drawings.

X520 GENERAL LIGHTING SWITCH (S1): 10A 240 V a.c., rocker operated, grid-switch with white plastic plate, for indoor installations in general, unless otherwise indicated.

X530 WEATHERPROOF SWITCH (S2): 10 A, 250 V, for installation outdoors, with weatherproof plate, synthetic gasket, weatherproof outlet box, on/off indication, IP 44 enclosure.

X535 REMOTE LIGHTING CONTROL PANEL FOR CONTACTOR CONTROL: multiple two way momentary on/off push switch assembly, with an 'on' pilot light for each circuit controlled (remote contactor). Panel and box are to be sheet steel construction, with see-through steel framed acrylic door and trim, handle and lock. Enclosure protection IP 42 to IEC 60947-1 and IEC 60529 for indoor installation and IP 55 for outdoor installation.

X580 DOUBLE POLE SWITCH (S20): rated 20 A or 45 A, as shown on the Drawings, 250 V a.c., tumbler operated, to BS 3676, with moulded plastic plate, as required in application area, marked (etched) with equipment controlled (i.e. air conditioner, water heater, etc.), and with red neon pilot light for on position. Switch is to be mounted to flush or surface box, as required or as shown on the Drawings, and provided with cord outlet and cord extension to equipment controlled.

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241:X6 SOCKET OUTLETS

X605 GENERALLY: to have injection moulded plastic base with self-adjusting, non-expanding contacts to prevent permanent distortion, arranged for side and/or back connection and with screw terminals accepting at least three parallel branch-circuit wires. Socket outlets are to be suitable for wall mounted as well as in trunking floor boxes, as shown on the drawings.

X610 TYPES: general purpose socket outlets are to conform with German standard practice (shuko type).

X615 DUPLEX SOCKETS are to be mounted in parallel under one common plate with break-off feature for two circuit connection.

X620 WEATHERPROOF SOCKET OUTLETS are to be any of the types indicated, enclosed in surface mounted cast metal box and with cover comprising spring-retained gasketted hinged flap. Enclosure is to be pre-designed box and cover for type of socket outlet specified.

X631 STANDARD SOCKET OUTLET - TYPE R01 (220 V SERVICE): single phase, 2P+E, white plastic plate, for plug with 3mm round pins at 19mm centers, with grounding in accordance with standard German practice and rated 16 A, 250V a.c. used for general indoor areas.

X635 WEATHERPROOF SOCKET OUTLET - TYPE R02 (220 V SERVICE): similar to type R01 but enclosed in surface mounted weahterproof box and with hinged cover (IP44).

X633 STANDARD SOCKET OUTLET - TYPE R04: Similar to R01, but in red colour for socket outlets fed from UPS. Socket outlet plate is to be designed for exterior labelling.

X675 POWER SOCKET OUTLET - TYPE R45 (380 V SERVICE): single outlet, 3P+N+E, 3-phase, polarized, rated 32 A, 380/415 V, with splash-proof plastic housing and hinged spring-return plate, and with matching plug 3P+N+E.

241:X7 PLUGS

X710 TYPE: compatible with type of socket outlet specified, break resistant, of impact resistant moulded insulating material (separable construction), with solid brass pins and cord grip and of shape providing easy hand-grip for removal.

X720 QUANTITY: supply number equal to 20% of total number of each type of socket outlet supplied.

X730 FUSES for standard British type sockets are to be standard 13 A cartridge fuses fitted in plug.

241:X8 SWITCH DISCONNECTOR (DISCONNECTING SWITCH)

X810 RATING: 500 V, 2, 3 or 4 pole, load break, short- circuit make, in accordance with IEC 408, utilization category 22 for heating and lighting loads, category 23 for motor circuits, and with ampere rating shown on the Drawings.

X820 DESIGN: non-fusible, air-break switch disconnector, single throw, safety type, housed in separate metallic enclosure with arc quenching devices on each pole.

X830 OPERATING MECHANISM: quick-make, quick-break, independant of operator, with external operating handle mechanically interlocked to prevent opening door unless switch is in open position. Switch disconnector is to have provision for by- passing interlock. Position of handle is to be positive and clearly indicated on cover.
X840 ENCLOSURE: general purpose sheet steel for indoor use IP 42, and weather-proof type cast-metal or sheet steel for outdoor installations IP 65, unless otherwise required or shown on the Drawings. Locking of operating handle is to be possible in open and closed positions.

241: X9 COMBINATION STARTERS SWITCH DISCONNECTORS

241:Y SPECIAL DEVICES

241:Y2 PHOTOELECTRIC CELLS

Y210 PHOTOELECTRIC CELLS: omnidirectional cadmium sulphide, hermetically sealed, with 2:1 on/off adjustment possible by moving light level selector, set to operate at illuminance levels shown on the Drawings. Unit is to include timer giving 3 minute delay to prevent false switching. Temperature range is to be -10 deg. C to +80 deg. C.

Y220 SAFETY: control is to be designed such that in case of failure, unit fails in the on position.

Y230 CONTACTS are to close or open as illumination level increases to set level with respect to requirements shown on the Drawings.

Y240 ENCLOSURE: heavy duty cast metal, with translucent dome of 'Lexan' (by G.E.) or other equal and approved, to protect against high ultra violet rays, and 180 deg. swivel base

and 16 mm threaded conduit mounting. Enclosure is to be weatherproof and protected against high winds and storms.

FIELD AND INSTALLATION WORK

241:1 INSTALLATION

1101 LOCATIONS: the Drawings generally show approximate locations of outlets and equipment. Exact locations are to be determined from interior finishings and detail drawings. Any condition that would place an outlet in an unsuitable location is to be referred to the Engineer. Locate switches at strike sides of doors, whether shown on the Drawings or not. In locating outlets allow for overhead pipes, ducts, variations in arrangement, thickness of finishings, window trim, panelling and other architectural features.

1151 MOUNTING HEIGHTS for outlet boxes and similar equipment are to be uniform within the same or similar areas. Mounting is to be as shown on the Drawings or as approved by the Engineer. Unless otherwise shown or instructed, mount lighting switches and socket outlets generally at 1200 mm and 300 mm from finished floor level respectively. Mount switches with long dimension vertical and operating handle, if of the toggle type, up when in the on position.

1201 SINGLE POLE SWITCHES are to switch the phase wire. Do not run neutral wire through switches having neutral shunt or bridge.

1301 ADDITIONAL OUTLETS to those shown on the Drawings are to be provided as required by equipment manufacturers for control or other wiring.

1401 EXPOSED OUTLET BOXES: securely fasten to wall with machine screws to permanent inserts or lead anchors.

1451 RECESSED OUTLET BOXES: make neat openings, to the satisfaction of the Engineer, allowing for thickness of finishings, and use extension rings if required. Repair damaged finishings to original condition before installation of fittings or plates.

1501 APPEARANCE: install exposed boxes and plates plumb, square and parallel to finished wall surface. Exposed plates covering recessed boxes are to rest neatly on wall surface without gaps, and fully covering the box.

1551 GROUPED OUTLETS: arrange neatly so that use of fittings is convenient and clear.

1601 WATERPROOF AND EXPLOSION-PROOF FITTINGS: follow manufacturer's instructions for installation and connection to conduit system to fully achieve required degree of protection.

1701 DAMAGED FITTINGS: reject damaged fittings or plates with damaged finish. Protect fittings and plates against damage after installation and until handed over.

1801 CONNECTION OF APPLIANCES:

where appliance is designed to adapt directly to outlet box, extend electrical wiring to incoming terminals inside appliance

where appliance is not designed to adapt to outlet box, install connecting wiring in flexible conduit firmly fixed to outlet box cover plate and to terminal box on appliance.

241:2 INSPECTION AND TESTS ON SITE

2051 VISUAL INSPECTION: fittings and equipment are to be inspected for fixing and workmanship.

2101 MEGGER TESTS are to include switch and socket outlet tests together with insulation resistance of wiring installations.

2201 OPERATION: devices are to be tested for operation and are to perform as intended at full load without any signs of heating.

2251 EQUIPMENT is to be insulation tested and observed, under full-load for not less than 3 days operation, with respect to undue heating and performance in general.

# 26 COMMUNICATIONS SYSTEMS

## 261 IP TELEPHONY SYSTEM

### 261:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A121 DEFINITIONS

A. ACL: Access Control List.

B. AD: Active Directory.

C. ASR: Automatic Speech Recognition.

D. AMIS: Audio Messaging Interchange Specification.

E. CDR: Call Data Recording.

F. CLI: Command Line Interface.

G. CLID: Calling Line ID.

H. CRTP: Compressed Real-Time Transport Protocol

I. CTI: Computer Telephony Integration.

J. DID: Direct Inward Dial.

K. DTMF: Dual Tome Multi-Frequency.

L. EMI: Electromagnetic Interference.

M. EN: European Standard.

N. GUI: Graphical User Interface.

O. HTTP: Hyper Text Transfer Protocol.

P. IP: Internet Protocol.

Q. IPSec: IP Security Protocol.

R. IVR: Interactive Voice Response.

S. ISO: International Standard Organization.

T. JTAPI: Java Telephony Application Programming Interface.

U. LAN: Local Area Network.

V. LDAP: Lightweight Directory Access Protocol.

W. MTTR: Mean Time To Repair.

X. MTBF: Mean Time Between Failures.

Y. PRI: Primary Rate Interface.

Z. PSTN: Public Switched Telephone Network.

AA. QoS: Quality of Service.

BB. SIP: Session Initialization Protocol.

CC. SLA: Service Level Agreement.

DD. SNMP: Simple Network Management Protocol.

EE. TAPI: Telephony Application Programming Interface.

FF. TDM: Time Division Multiplexing.

GG. TFTP: Trivial File Transfer Protocol.

HH. UTP: Unshielded Twisted Pair.

II. VLAN: Virtual Local Area Network.

JJ. VPIM: Voice Profile for Internet Mail.

KK. VPN: Virtual Private Network.

LL. WAN: Wide Area Network.

MM. WWW: World Wide Web.

## A131 SUMMARY

A. This Section includes the electronic components required to provide and operate a carrier grade IP-based Telephony Communications System which include central call routing equipment and telephone instruments for use on communication and data-processing equipment.

B. All hardware shall be current offering of the Manufacturer, and be receiving the highest level of support offered by the Manufacturer.

C. All hardware shall be new equipment.

D. The scope of work consists of the design, engineering, procurement, and installation of components required for the operation of an IP-based Telephony Communications System and are based on, but not limited to, the following:

1. Call Processing Unit and software.

2. Gateways.

3. Signaling Servers.

4. IP terminals and client devices.

5. Applications and network management.

E. The main IP Telephony server(s) shall be installed in the Server Room located in the Cargo and Container Building, ground floor.

## A151 DESCRIPTION OF WORK

A. Purposes

1. The present document is to describe the IP-based Telephony Communications System to be installed as part of the Employer's IT systems.

2. 25% spare capacity is required at all levels of the system.

3. The software licensing shall be for the entire system with no limitation on the number of workstations or standard end-users.

B. Due to the criticality of information systems that may reside on it, the IP-based Telephony Communications System shall be a fully managed and monitored system. This system shall provide the ability to manage accounts and security as well as performance, configuration and faults.

C. Scope of Works

1. The Scope of Works shall include, but not be limited to, detailed engineering, coordination, manufacture, supply, transportation, delivery, installation, testing, commissioning, setting to work, training and maintenance services during the 24-month Warranty Period, Operation and Maintenance services (as an option to the Employer) for the IP-based Telephony Communications System of the building. This shall include at least the following tasks:

a. Coordination with the Employer's existing contractors, operators, and providers of interfaced systems,
b. Project management,

c. Planning management,
d. Detailed functional analysis until approval by the Employer,
e. Finalization of system to the approval of the Employer,
f. Detailed software specification to the approval of the Employer,
g. Delivery of the interface control document to the approval of the Employer,
h. Software development, complying with the detailed software specification,
i. Supply of needed IP-based Telephony Communications System equipment and components,
j. Transport, unloading, and storage on the site of the required equipment and components,
k. Coordinating with local and long distance carriers to address the system requirements, if required.
l. Equipment installation,
m. Software installation,
n. System installation and configuration,
o. System integration with interfaced and existing systems,
p. Complete testing of the system (unit tests, integration tests, final acceptance tests, users' tests, etc.),
q. Training,
r. System implementation in the Employer's premises,
s. System roll-out,
t. System maintenance after successful initial proving period during Warranty,
u. Supply of spare parts for 2 years,
v. System maintenance tools delivery,
w. Writing and delivering of documentation (user's manual, maintenance manual, test reports, etc.),
x. Operation and Maintenance as an option to the Employer.

2. Technical specifications and architecture principles are generic and can be used to future extensions.

3. Details of the elements included:

a. Request for Proposal of the following elements is explicitly specified in this Section.

1) Provision, delivery and installation of the following equipment, but not limited to:

a) Call Processing System,
b) Public Media Gateways,
c) Signaling Servers,
d) IP Terminals and Client Devices,
e) Applications (unified messaging, IP contact center, Conferencing, web collaboration, etc.) as options to the Employer,

f) Associated element and/or network management tools with duly dimensioned hardware.

2) Procurement, delivery and setup to work of IP telephones. The following Categories shall be considered:

a) Category 1 phones.
b) Category 2 phones.
c) Category 3 phones.
d) Category 4 phones.

Category 1 IP phones are considered to be of the highest quality with sophisticated features and capabilities.

3) Integration and support services.
4) Warranty of the above equipment.
5) Operation and Maintenance services as an option to the Employer.

4. Specific Requirements:

a. Integration with existing network elements with full responsibility to the Contractor in order to make a coherent system. This work shall be carried out in close coordination with the Employer's representative.
b. Manufacturer technical validation and endorsement of the design documentation and implementation shall be provided.
c. Risk analysis on the design with advantages and drawbacks will have to come from the Manufacturer.
d. Post deployment auditing by Manufacturers shall be specified in the documents,
e. Submission of credential of the trainers shall be approved by the Manufacturer and by the Employer.

5. The Contractor shall be responsible for the provision of the licenses for all software, programs and modules provided for the Works including those developed and modified by the Contractor. The appropriate licenses supplied by the Contractor shall enable the Employer to use, modify, and develop the software, programs and modules for the works supplied under this Contract. The software licensing shall be for the entire building with no limitation on the number of workstations or standard end-users.

D. Coordination

1. Coordinate Works of this Section with the Employer's:

a. Departments, operators, contractors, organization, etc.
b. Construction and implementation works.

c. Structured cabling network, both for communication room configurations and for connectors' type (electrical and optical).
d. Fiber optic cabling infrastructure.
e. Active communication and data processing equipment.
f. Workstations and servers suppliers.
g. IT systems providers using the IP-based Telephony Communications System.
h. Others (list given above not exhaustive).

2. Meet jointly with representatives of concerned organizations, contractors, and Employer's Representatives to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.

3. Record agreements reached in meetings and distribute record to other participants.

4. Adjust arrangements and locations of equipment in technical rooms and way of wiring closets to accommodate and optimize arrangement and space requirements.

E. Variant and Options

1. The Contractor should propose no variant.

2. Options consisting in additional provisions to the basic system may be submitted to the Employer for approval, with specifications, characteristics, aiming and full particulars of calculations and equipment selections. All options shall be priced separately.

F. Software

1. GENERAL

a. The availability performance shall be 99.999% on a monthly average combined for all interdependent systems and it shall be the responsibility of the Contractor to ensure the overall availability.
b. The maximum time between detection of an event and its display on a workstation shall be of 3 seconds, under normal operating mode (for a mean load on network and on servers).
c. The MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on-site, but shall exclude the response time.
d. The Contractor's response time shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.

e. In order to reach the requested MTTR and MTBF, modular conception and quick interchange of modules are required for the Data Network components.
f. Redundancy:

   1) At all levels of the architecture, data redundancy shall be ensured. The detailed design of the Contractor shall highlight the actions adopted to implement this redundancy.

2. SOFTWARE REQUIREMENTS

a. The Contractor shall refer to IEEE 610.12 “IEEE Standard Glossary of Software Engineering Terminology” for the definition of software related terms.
b. Software Availability (SA) is defined as the probability that the program is performing successfully, according to specifications, at a given point in time. The Software Availability shall be 99.999%.
c. Task Crash, which is defined as the unexpected termination of an executing task resulting in the system not being able to perform the task functions successfully according to specifications, for any reason, is not allowed.
d. System Crash, which is defined as the unexpected system halt resulting in the system not being able to continue the operation of the machine, for any reason, is not allowed.
e. The Contractor shall adhere to recognized structured analysis and design methods throughout the design process.
f. All compilers and code generators shall be of the latest version and in compliance with international standards. No undocumented or non-standard feature of the language or operating system shall be used. Main and disk memory requirements shall be minimized.
g. The Contractor shall ensure that all software delivered to site shall be accompanied by evidence that the media is free of viruses.
h. No software Beta version shall be used in the network unless specifically authorized by the Employer.

3. DESIGN CONSIDERATIONS

a. The Contractor shall use a suitable module design method to enable the software to be easily modified to cope with additional functionality providing I/O dialogues, billing equipment and controlling equipment. These additional functionalities are to be proposed as optional.
b. Network management software to be provided with, but not limited to, impact analysis, event resolution, policy management, problem diagnosis, real-time trending, service monitoring, SLA compliance, and reporting and out-of-band management stress as per community SLA reporting capabilities.
c. The expansion of software shall not cause any degradation of the performance of the system.

4. SOFTWARE EXPANSION REQUIREMENTS

a. Software databases working in an off-line or on-line mode of operation should be designed to allow for ease of expansion. Where new database structures are implemented with fixed sizes then at least 30% spare capacity of each entry type and attribute shall be provided.
b. The Contractor should develop software with possible expansion provision of porting to other hardware platforms, where practicable. To achieve this, a structured language and compiler should be used, subject to the approval of the Employer's Representative.

5. HARDWARE EXPANSION REQUIREMENTS

a. The hardware shall meet performance requirements considering that at least 25% spare capacity shall be provided.

6. SERVICE LIFE

a. The system should have been designed for a service life of ten years.

G. Operational Constraints

1. The system will run 24 hours per day, all the days of the year.

## A161 SUBMITTALS

A. Design Submission: Shall include, but not limited to:

1. Equipment Datasheets must include (at least) the following information:

a. Product performance and existing features,
b. Environment requirements (Power, temperature, etc.),
c. Features, software and hardware releases roadmap on the next two years,
d. Standardized tests passed and results and available product certificates,
e. Product compatibility matrix with other manufacturers/vendors (specify level of testing in operation, lab test, declarative or theoretical),
f. MTBF.

2. System Requirement and Design Specification

a. System Architecture and justification.
b. Justification of performance requirements.

3. Management software datasheets must include (at least) the following information:

a. Product performance and existing features,
b. Known limitations (number of network elements managed, number of administrators, number of clients, size of the database, etc.),
c. Hardware requirements (storage, computation, processor needs, operating system, display, etc.),
d. Features and software releases for the next two years,
e. Standardized tests passed and results and available product certificates,
f. Product compatibility matrix with other Manufacturers/Vendors (specify level of testing in operation, lab test, declarative or theoretical).

4. Installation, configuration, integration and support offers must detail:

a. Level of qualification of the personnel involved. Detail if some parts shall be subcontracted.
b. Training program provided by the Manufacturer to the Contractor teams and related certificates.
c. Project structure and localization during operations (distinguish local and remote teams).
d. Detailed responsibility matrix for a task by task responsibility assignment.

5. Technical documentation and trouble shooting guides shall be provided in English & Arabic, both paper and electronic version, for each type of equipment in the offer.

6. Product Certificates: Signed by Manufacturers certifying that products furnished comply with requirements.

7. Human Machine Interface (HMI) Design:

a. For dedicated Workstation users.
b. For standard end-users.

8. Software Requirement and Design Specification:

a. Software Architecture and justification (e.g.: off-the-shelf and specific software, etc.).
b. Justification of performance requirements.

9. Test Plan:

a. The Contractor shall provide Test Plan on the testing methodologies used for various tests involved throughout different stages of the Works. This shall also include the plan for integrated tests for interface with other systems. The Contractor shall submit the Test Plan for approval by the Employer's Representative.
b. Test program shall be part of the test plan.

c. In establishing the test program, the Contractor and the Employer's Representative shall agree which activities shall be attended by the Employer's Representative.
d. After approval, the Test Plan shall be amended as required during the life of the Project to reflect changes in system design and the identification of additional testing requirements.

10. Maintenance and Warranty offers must detail:

a. Comprehensive cost structure according to committed GTI, GTR and MTBF.
b. Maintenance stock dimensioning.
c. Distinguish maintenance during warranty period and after.
d. Teams' organizations (distinguish local and remote teams, give associated manpower).
e. Hardware repairs and software patch support procedures.

B. Project Schedule

1. Provide a detailed Build Plan that includes, but is not limited to:

a. All activities required to deliver a production ready system to the Employer.

1) The duration of each activity in days,
2) The resources required to complete each activity,
3) Any dependencies amongst activities.

C. Product Data

1. Include detailed Manufacturer's specifications and data sheets for each system component.

2. Include data on features, ratings, and performance for each component specified.

3. For each type of equipment, submit data for approval including catalogues and literature, sufficiently detailed for engineering purposes, and with full description of components and operating parameters.

D. Shop Drawings

1. Indicate layout, wiring diagrams, and dimensions.

2. Locate devices and components on drawings.

3. Submit drawings for approval including, but not limited to, the following:

a. Detailed system schematic diagram,
b. Layout of network components, network management system, etc.

c. System labeling schedules, including electronic copy of labeling schedules in software and format selected by the Employer's Representative.

4. Complete electrical and physical characteristics of network components, network management system, etc.

5. Complete system wiring diagrams, size and type of cables, enclosures, and terminal, splice boxes etc., and routing plans of wiring system.

6. Include dimensioned plan and elevation views of components. Show access and workspace requirements.

E. Manufacturer's Installation Instructions

1. Provide Manufacturer's installation instructions.

2. Certificates signed by Manufacturers of equipment certifying that the provided products comply with contract specified requirements.

F. System Operation Description

1. Include method of operation and supervision of each component and each type of circuit, and sequence of operations for manually and automatically initiated system inputs.

2. Description must cover this specific Project; Manufacturer's standard descriptions for generic systems are not acceptable.

G. Product Certificates

1. The Contractor shall provide certificates signed by Manufacturers of components certifying that the provided products comply with requirements.

H. Qualification Data

1. For firms and persons specified in "Quality Assurance" an article shall be written to explain and demonstrate their capabilities and experience.

2. To include lists of completed projects with project names and addresses, names and addresses of architects/engineers and owners, and other information specified or required by the Employer's Representative.

3. An experienced Contractor, which is an authorized representative of the Manufacturer, for both installation and maintenance purpose, is formally required for this Section.

I. Tests and Certificates

1. Test Specifications as defined in the Test Plan shall be submitted for Approval.

2. Submit complete certified Manufacturer's type and routine test records, in accordance with the Standards specified in "Quality Assurance" Article.

3. It shall specify test results for compliance with performance contract requirements.

4. Include record of signal ground resistance measurement certified by the Contractor.

J. Field Test Reports

1. As specified in "On-Site Tests and Inspections" Article of this Section, the Contractor shall indicate and interpret test results for compliance with system description and performance requirements.

K. Record (As-Built) Drawings

1. Complete wiring diagrams, including complete terminal strip layout and identification, and wire termination and tagging for all conductors.

2. Locations for all components installed and/or connected to under this Specification.

L. Sample Warranty

1. Copy of Manufacturer's warranty, stating obligations, remedies, limitations, and exclusions.

2. Provide copy of sub-contractor's warranty certificates.

3. Provide Contractor's warranty certificates.

M. Maintenance Data

1. For products and systems, the Contractor shall include maintenance manuals.

2. The Contractor shall include data for each type of product, including all features and operating sequences, both automatic and manual.

3. The Contractor shall include user's software data and recommendations for spare parts and components to be stocked at Project site.

## A201 REGULATIONS AND STANDARDS

A. Rules

1. The supply shall be conformed to requirements of referenced industry standards, applicable sections.

2. The supply shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.

B. Standards

1. System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC)

   a. ISO/IEC 11801: latest edition regarding Information Technology and Generic Cabling for Customer Premise.
   b. ISO 14443 A or B Standard.
   c. EIA/TIA 568, Commercial Building for Telecommunication Wiring Standard.
   d. EIA/TIA 569, Commercial Building for Telecommunication Pathways and Spaces.
   e. EIA/TIA 606 for Telecommunications Infrastructure: This document provides the user of this document with guidelines and choices of classes of administration for maintaining telecommunications infrastructure.
   f. EIA/TIA 607 Commercial Building Grounding (Earthling) and Bonding Requirements for Telecommunications (ANSI/J-STD-607-A-2002).
   g. IEC 60754-1 & 2 Test on Gases Evolved During Combustion of Materials from Cables and Test on Gases Evolved During Combustion of Electric Cables.
   h. IEC 61034-1 & 2 Test and Measurement of Smoke Density of Cables Burning under Defined Conditions.
   i. IEC 60331 Part 11& 12, Tests for Electric Cables under Fire Conditions.
   j. IEC 60332 Tests on Electric Cables under Fire Conditions.
   k. IEC 60364-1 Electrical Installations of Buildings, Fundamental Principles, Assessment of General Characteristics, Definitions.

2. IEEE: Institute of Electrical and Electronics Engineers

   a. Comply with the latest issues of material and test standards which have been developed and published by the Institute of Electrical and Electronics Engineers (IEEE) 802 Working Group (WG) data communications.

3. ISO: International Standardization Organization:

a. It promotes the development of international standardization with scientific, technological and economic activities.
b. The Technical Committee 97, Information Processing, developed a seven-layer communications reference model that allows multiple protocol and multiple vendor environments to interconnect and operate with one another.

4. Comply, as often as possible, with both ITU-T (International Telecommunications Union) recommendations and US standards. When standards are not compatible in both Europe and US (e.g. telecom interfaces SDH STMx vs. SONET OCx) detailed compatibility and interface availability shall be provided.

5. Building Industry Consulting Service International (BICSI):

a. Publishes the Telecommunications Distribution Methods Manual (TDMM), which is a comprehensive collection of accepted practices in the design and methodology of communications systems. BICSI provides a competency examination for the professional designation as a registered Communications Distribution Designer.
b. This manual should be used as a reference only.

6. Network Equipment Building System (NEBS):

a. Level 1, Level 2, and Level 3 are applicable to these section.

C. Precautions:

1. The above list is a partial list issued from standard organization. Additional consideration may be required to provide protection of communications equipments, data processing equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

## A211 QUALITY ASSURANCE

A. Requirements

1. All Works shall be executed and controlled by a quality management system in accordance with the requirements of ISO 9001.

2. This system shall comprise all the participants to the Contract within the Contractor’s teams and its sub-contractors.

3. The Quality Assurance Plan shall be based on quality manuals of the Contractor and sub-contractors.

4. The Contractor shall nominate from the beginning of the Project, the person in charge of quality assurance of the whole project, who is directly linked to the Project Director.

5. The Contractor should establish from the beginning of the Project, the Quality Assurance Plan based on Contractor's quality system that should define:

    a. Scope of Quality Assurance Plan, with conditions of validity and revision,
    b. Approach and structure of the Contractor's quality management system to fulfill the requirements of the Contract and ISO 9001,
    c. Organization retained for the Project with sub-contractors list,
    d. Details of how the Contractor proposes to manage sub-contractors and to ensure that the relevant quality system requirements of ISO 9001/2 are observed and implemented by the sub-contractors in the execution of the works sub-contracted,
    e. The quality plans of the Contractor.

B. Manufacturer Qualifications

1. A firm specializing in providing IP-based Telephony Communications System, similar to that indicated for this Project and with a record of successful in-service performance.

2. Manufacturer's systems shall be, as often as possible, a standard "off-the-shelf" package utilizing the latest hardware and software technology. Any major system development effort necessary to meet specified requirements is unacceptable. Even if this system is a new concept, it should not require huge development and shall be based on existing and proven technologies.

3. Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, parts, and emergency maintenance and repairs for overall system at Project site with eight hours of maximum response time.

C. Installer Qualifications

1. An experienced Installer who is an authorized representative of the equipment Manufacturer for both installation and maintenance of Manufacturer's equipment, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance.

D. Materials and Workmanship

1. They shall conform to the latest issue of all industry standards, publications, or regulations referenced in this Section, including the following, as applicable:

    a. Regulations and Standards: System components, parts, and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).

b. Compliance with Local Requirements: Comply with applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Employer's Representative, in writing.
c. Conform to requirements of referenced industry standards, applicable Sections.

E. Source Limitations

1. For each category of technology used for the IP-based Telephony Communications System, obtain system components from one Manufacturer who shall assume responsibility for the system components and for their compatibility.

## A221 COORDINATION

A. Coordinate with the Employer to confirm location of equipment, power supply, air-conditioning and ventilation of equipment in room.

B. Meet jointly with representatives of concerned organizations, contractors, and Employer's Representatives to exchange information and agree on details of project implementation, transition plan, equipment arrangements and installation interfaces, etc.

C. Record agreements reached in meetings and distribute record to other participants.

## A231 TESTING AND REPORTS

A. The Contractor shall test all components and circuits of the IP-based Telephony Communications System after installation to ensure functionality and performance within industry approved guidelines.

B. A written report shall be submitted describing testing procedure and detailing test results.

C. The Contractor shall provide and supply all necessary technical and skilled manpower, tools, test equipment, materials and transportation required for performing system and components testing.

## A241 RECORD DOCUMENTATION

A. Operation and Maintenance manuals:

1. The Contractor shall submit full system documentation for the installed IP-based Telephony Communications System and all ancillary equipment such as the Network Management System.

2. System documentation shall consist of:

    a. A complete set of product data for all component parts.
    b. A complete set of operations manuals for all components of the system.
    c. Maintenance manuals for all components of the system and for the system as a whole.

B. Test procedure, data and results from acceptance testing.

## A251 WARRANTY

A. General Special Warranty

1. Manufacturer's Warranty: Provide written warranty, signed by the Manufacturer and the Installer agreeing to replace system devices and equipment that fail in materials or workmanship within specified warranty period.

B. Experimental Period

1. There shall be an experimental period of 90 days after successful testing and commissioning of the system, but before issuance of substantial completion certificate. During this period, the Contractor shall undertake supervision and responsibility for operation of the system under actual site conditions. If any malfunctioning or anomaly noted on the system during this period, it shall be attended immediately. The experimental period will restart automatically from the date of clearing such troubles and start normal operation.

2. During this period, the Contractor shall fully demonstrate the system performance under actual operation conditions. This demonstration is to confirm, to the satisfaction of the Employer's Representative, that the system is free of remarks and is ready for provisional taking over.

3. After the satisfactory completion of this period, the system is to be taken over by the Employer, as per Contract Conditions, whereby the Warranty Period is to commence.

C. Warranty Period

1. Two years from the satisfactory completion of the Experimental Period.

2. During the Warranty Period, the Contractor shall undertake Maintenance actions as defined in the Maintenance and Warranty Article.

3. During the Warranty Period, the Contractor shall provide, at its own cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.

D. Manufacturer Product Performance

1. The Contractor shall provide a Manufacturer endorsed and backed extended 10-years product, performance, application, and labor warranty which shall:

   a. Warrant against defects in materials and workmanship (extended product warranty) for a period of 10 years.
   b. Warrant that all cabling components of the installed system will meet or exceed the specifications of TIA/EIA 568C and ISO/IEC IS 11801 (performance warranty) for a period of 10 years.
   c. Warrant that all unshielded/shielded twisted pair cabling links/channels will meet or exceed the attenuation and NEXT requirements of TIA/EIA TSB 67 and ISO/IEC 11801 (performance warranty) for a period of 10 years.
   d. Warrant that all fiber links/channels shall meet or exceed the loss and bandwidth requirements of TIA/EIA TSB 67 and ISO/IEC 11801 (performance warranty) for a period of 10 years.
   e. Warrant that the system shall be application independent and shall support both current and future applications that use the TIA/EIA 568C or ISO/IEC 11801 component and link/channel specifications for cabling (application warranty), for a period of 10 years.
   f. Warrant that all labor attributable to and required by the above shall be supplied at no cost to the Owner for a period of 10 years.

## A261 COMMISSIONING

A. Purpose

1. In-System Commissioning

   a. The Contractor is responsible for the equipment installation in the system, so that the system stays globally functional. Therefore, equipment commissioning must be done through demonstration of product capability and compliance with requirements when wired and configured in the system.
   b. Test link system and power supply redundancies by unplugging redundant links.
   c. Check recovery times.

2. The Contractor shall be required to perform a range of Site Acceptance Tests on-site for each individual sub-system to demonstrate that all items have been correctly installed and adjusted on a location by location basis and that the sub-system operates in every respect in accordance with the Specifications.

3. During this phase the equipment are powered and the automation and networking are gradually integrated layer by layer.

4. The tests shall be performed by the Contractor and witnessed by the Employer's Representative.

5. Any defects, which may become apparent during the course of these tests, shall be immediately rectified by the Contractor at his expense.

6. The Site Acceptance Test Specifications shall be prepared by the Contractor and submitted for Approval.

7. All Site Acceptance Tests shall be carried out in the presence of the Employer's Representatives who shall sign off the testing documentation on satisfactory completion of the tests.

8. The Site Acceptance Test Specifications, at every level, shall be subjected to configuration management and change control by the Contractor.

9. If modification or reprogramming is required as a result of the tests, all affected parts of the Site Acceptance Tests, as determined by the Employer's Representative, shall be re-tested.

10. The results of the Site Acceptance Tests, version of software and hardware tested, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representatives.

B. Tests

1. Those tests are divided into 2 sub-phases.

2. Preliminary Testing:

   a. Automatism / Electrical:

      1) Powering Tests with electricity,
      2) Control of Input/Output,
      3) Control of the safety measure either personal or material,
      4) Test of local mode operation.

   b. System / Software Tests:

      1) Test of the System,
      2) Test of the Supervision Workstation user interface,
      3) Test of the portable Terminal user interface.

3. Test of the System:

   a. The tests performed during this phase are performed with and without loading conditions.

      1) Testing the crippled mode (Safe shut down consecutive to loss of energy, etc.),

## A271 MAINTENANCE

A. Support

1. The Contractor must offer a comprehensive explanation of its Service Level Agreement (SLA) policy. The SLA should cover at least the following performance terms:

    a. 99.999% availability. GTI and GTR should be guaranteed accordingly.
    b. Emergency level 24/24, 7/7 phone support shall be available. Distant intervention on system must be offered.
    c. High-level problem investigation support must be offered 5/7 during working hours.
    d. Maintenance stocks must be properly sized by the Contractor in order to match operational quantities replacement needs given Manufacturers MTBFs for each equipment and components within the system.

2. Maintenance service must include:

    a. Contract lifetime software patching for revealed problems during operations.
    b. Contract lifetime hardware replacements on established malfunctions or weaknesses generating repetitive loss of service quality
    c. Repairs in reasonable time for factory returned equipment.

B. Maintenance Service

1. During the Warranty Period, Manufacturer or factory-authorized agency shall maintain a service center capable of providing spare parts and emergency maintenance and repairs for the overall system at Project site 7 days a week and 24 hours a day. Competent personnel shall be dispatched to rectify stoppages at any time during the day or night when being called on by the Employer.

2. The Contractor shall submit a Service-Call Report to be sent to the Employer immediately following every call out, indicating the time of call out visit, cause, remedial action taken and the time that the service was restored.

3. A Maintenance Manpower Plan shall demonstrate the Contractor’s committed resource level available for all types of activities to be carried out within the Warranty Period. Such plan shall be submitted for Approval six months before commencement of the Warranty Period.

4. The Contractor’s response time, during the Warranty Period, shall not exceed 1 hour. The response time is defined as the time that elapses

between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.

5. During the Warranty Period, the MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on-site, but shall exclude the response time.

6. During the Warranty Period, the monthly average of the Repair Time shall be lower or equal to six minutes for each device. This performance will be checked.

7. The Contractor shall liaise with the Employer's Representative and carry out safety and performance inspections for the installation on-site. Any necessary adjustments to the installation shall be made within 14 days of completion of such checks. A Safety and Quality Report shall be submitted, no later than 14 Days after such safety and performance checks, for the Employer's Representative's approval.

8. The Contractor shall provide at least four inspection visits at six-month interval during the Warranty Period.

9. The Contractor shall be responsible to clear away from the Site all surplus materials, rubbish, temporary works of every kind and leave the whole of the Site and installation clean and in a workmanlike condition to the satisfaction of the Employer's Representative, upon completion of each item of the repair, and maintenance works.

C. Maintenance Performance Data

1. Updates

   a. The system will have to be conceived to facilitate the updates that will take place throughout its life. The replacement in exploitation of a version of software by the following one must be an easy operation, without risk, rapid and reversible.
   b. This update shall be transparent for the user and shall be done without interruption of the service.

2. Corrections

   a. In the event of error, the system shall have, as soon as possible, to store in a file a certain amount of information allowing the correction of this error, e.g. entries in the transactions, faulty operations of the statistics, etc.

## A281 GLOBAL SYSTEM REQUIREMENTS

A. General

1. Coordinate the features of materials and equipment so they form an integrated system. Match components and interconnections for optimum future performance.

B. Expansion Capability

1. Unless otherwise indicated, provide equipment extensions capabilities for five years after each equipment delivery. The Contractor shall inform the Employer when extension limit is to be reached. Extension limit means:

   a. Equipment in a given area unable to accommodate 20% further increase in network elements to connect. Limitation shall be made specific.
   b. System management tools are unable to accommodate 20% further increase in number of ports or elements. Limitation shall be made specific.

## A291 SPARE PARTS AND EXTRA MATERIALS

A. Contractor shall provide Manufacturer recommended spare parts for all major components in the system for two years fault free operation.

B. However, a minimum of 2% peripherals of each type installed, but not less than one from each type shall be included in the deliverable irrespective of Manufacturer recommendation.

C. During the Warranty Period, the Contractor shall provide, at his cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.

D. The Contractor shall guarantee the flow and availability of the spare parts without a major design change for at least ten years period.

## A801 APPROVED MANUFACTURERS

Obtain IP Telephony equipment from one of the following:

| | |
|---|---|
| Alcatel-Lucent | (France) |
| Cisco | (U.S.A.) |
| Mitel | (Canada) |
| Avaya | (U.S.A.) |

Siemens (Germany)

or other equal and approved.

PRODUCTS AND SYSTEMS

261:Y SYSTEM ARCHITECTURE

261:Y1 DESCRIPTION

Y110 The Contractor shall provide a full description of the proposed system architecture. This shall be structured so anyone reading only this section has a clear understanding of the system. Diagrams explaining this architecture shall be included. The Contractor shall also specify the model names and version numbers of all relevant components of the system.

Y115 The solution shall be able to integrate with the public switched telephone network (PSTN), and any other telephony systems, e.g. DECT, GSM, WiFi, etc.

Y120 The solution shall be centralized from a call processing and signaling perspective.

Y125 The system architecture shall support multi-Manufacturer interoperability with other Manufacturer's products and across any QoS infrastructure.

Y130 The system architecture shall support end-to-end QoS. This shall include but not be limited to traffic marking, enhanced queuing services, link fragmentation and interleaving, CRTP, low latency queuing, link efficiency, traffic shaping, and call admission control.

Y135 The system architecture shall provide bandwidth management and call admission control to guarantee at all times that the network and LAN/WAN links are not over subscribed.

Y140 The system architecture shall be able to support open industry standard devices such as H.323, SIP, etc. This shall include the support of analog and digital phones.

Y145 The system architecture shall support remote soft phones. The Contractor shall state any additional equipment or software that maybe required at the remote location.

Y150 The system architecture shall have local survivability capabilities provided for remote sites during a WAN outage for remote sites hosted off of a central server.

Y155 The system architecture shall be able to provide easy addressing scheme of the IP phones, such as Dynamic Host Control Protocol (DHCP), without having to change the addressing scheme of the existing IP data network.

Y160 The system shall support all relevant industry standards listed below. The Contractor shall state any standards that are not supported indicating when he is expecting to support it:

The Low Latency Queuing feature

Priority Queuing

Class-Based Weighted Fair Queuing (CBWFQ).

Committed Access Rate.

Compressed Real-time Protocol (CRTP).

Dynamic Host Configuration Protocol (DHCP).

Differentiated Services (DiffServ).

Domain Name Service (DNS).

FAX - Group 3 (ITU-T recommendation T.4 Fax group 3 is the most common type of fax machine transmitting on A4 paper. The machine scanning format is digital and operates at rates between 9.6 and 14.4 Kbps).

FAX - Group 4 (IUT-T recommendation T.6 and supports two-dimensional image compression, compressing the line width as well as the line length).

G.711 Pulse Code Modulation (PCM) of Voice Frequencies.

G.726 Adaptive Differential Pulse Code Modulation (ADPCM).

G.728 Coding of Speech at 16 Kbps using Low-Delay Algebraic Code Excited Linear Prediction (LD-ACELP).

G.729 Coding of Speech at 8 Kbps using Conjugate Structure Algebraic Code Excited Linear Prediction (CS-ACELP).

G.729a Annex A Reduced Complexity 8 Kbps CS-ACELP Speech Codec.

H.225 Call Signaling Protocols and Media Stream Packetization for Packet based Multimedia.

H.245 Control Protocol for Multimedia Communications.

H.323 Packet Based Multimedia Communication Systems.

IP Precedence.

Internet Protocol version 4 (IPv4).

Internet Protocol version 6 (IPv6).

Lightweight Directory Access Protocol (LDAP)

Media Gateway Control Protocol (MGCP).

Policy Based Routing.

Q.931 Manages Call Setup and Termination.

Priority Queue Weighted fair Queuing (PQWFQ).

Random Early Discard (RED).

Resource ReSerVation setup Protocol (RSVP).

RTP Control Protocol (RTCP).

Real-time Transport Protocol (RTP).

Real-time Streaming Protocol (RTSP).

Session Initiation Protocol (SIP).

T.120 Data Protocols for Multimedia Conderencing

Simple Network Management Protocol (SNMP).

Transmission Control Protocol / Internet Protocol (TCP/IP).

T.37 Internet Fax.

T.38 IP Based Fax Service Maps.

User Datagram Protocol / Internet Protocol (UDP/IP).

Voice Profile for Internet Mail (VPIM)

Weighted Queuing.

Weighted RED.

IEEE 802.1d Spanning Tree Protocol.

IEEE 802.1p Prioritization Technique/Layer 2 QoS.

IEEE 802.1q VLAN Tagging.

IEEE 802.3 Ethernet (CSMA/CD).

IEEE 802.3af Power over Ethernet (PoE).

IEEE 802.1X Port-based Network Access Control (PNAC).

## 261:Y2 SYSTEM RELIABILITY, SECURITY AND AVAILABILITY

Y210 The system shall be capable to provide high availability, redundancy and fault tolerance. The Contractor shall specify the components that can be duplicated in the system. In addition, a full description of the system's redundancy capabilities shall be provided.

Y215 The system shall include all components, features and facilities to deliver 99.999% uptime. This shall address as a minimum bandwidth, packet loss, round trip delay and jitter.

Y220 The IP-based Telephony Communications System shall provide as a minimum password protection, session encryption, IP address filters, log information about failed password attempts, etc. to prevent un-authorized modifications to the system servers, to the system gateways, and to the system IP phones.

Y225 The system shall have advanced built-in security features such as external firewalls/Network Address Translation (NAT), firewalls, VPN, etc. The system shall also be able to accept third-party monitoring software that can be used to detect system status.

Y230 The system shall be able to track failed password entries in a single session and across multiple sessions. The system shall also automatically disconnect the caller and/or lock out the user after a configurable number of failed attempts.

Y235 The system architecture shall support operator system and server clustering for redundancy. The Contractor shall specify the maximum number of clusters his system can support and the maximum number of active users supported per cluster.

Y240 The Contractor shall specify the highest number of IP devices currently supported under a single instance of the software and the number of IP devices supported by a cluster.

Y245 The system shall have a web-based or GUI-based administration tool. This administration tool shall have the capability to manage all systems within an enterprise simultaneously using a single interface.

Y250 The system shall have protection mechanisms against viruses and other attacks, and intrusion detection to insure the proper operation of all components.

Y255 The system shall have toll fraud protection capabilities.

Y260 The Contractor shall guarantee the continuous operation of the system by provisioning for UPS or "battery" back-up systems.

## 261:Y3 SYSTEM FEATURES

Y310 The IP-based Telephony Communications System shall provide the following features. The Contractor shall specify any features that the system does not support and/or any additional features supported by his system:

Account codes and call-detail-record (CDR) field entry

Call-back busy subscriber and camp-on

Per-phone call-coverage rules

Call hold and retrieve

Call transfer

Call pickup directed

Call pickup local group

Call pickup explicit group

Call waiting

E911 with two emergency location numbers per zone; unlimited zones per site

Eight-party impromptu conferencing

Directory services using XML

Temporary conferencing (8 parties)

Meet-me conferencing (32 parties)

Music on hold (MoH): Internal or external source

Night service bell or call forwarding

Overlay extensions for enhanced call coverage

Called-name display for overlay extensions

Per-call caller ID blocking

Secondary dial tone

Standards-based network call transfer and call forwarding using H.450

Additional system speed-dial option through XML service

Time-of-day and day-of-week call blocking

Customizable called-name display

Support of Survivable Remote Site Telephony (SRST) fallback service phone autoregistration

Basic automatic call distributor (B-ACD) (three queues) with Automated Attendant and call statistics

Display of number of calls in queue on IP phone

Agent log in and log out of B-ACD hunt group

Secure Real-Time Transport Protocol (SRTP) providing media encryption for calls on the IP network

Secure voice IP phone certificate authentication and provisioning plus secure device signaling using Transport Layer Security (TLS)

Busy Lamp Field monitoring of conference directory numbers and call-park slots

261:Y4 CALL PROCESSING SYSTEM

Y410 The system shall have the most recent software release at the time of delivery. The Contractor shall provide a timetable of all scheduled software releases and upgrades.

Y420 All system changes and software upgrades shall be able to be performed on-line with minimal interruption and/or disturbance of the running system.

Y430 The system shall have a back-up procedure for the operating software, which includes up-to-date moves and changes.

Y440 The system shall support Computer Telephony Integration (CTI), Telephony Application Programming Interface (TAPI) and Java Telephony Application Programming Interface (JTAPI) applications.

Y450 The Contractor shall list all partner programs for third-party applications development.

Y460 The call processing system shall be based on open standards (H.323, H.248 and SIP) and has an open architecture operating system.

Y470 The system shall be scalable and modular and be able to support a variety of distributed configurations.

Y480 The system shall provide an industry leading solution for remote offices that need to be effectively networked to a main location, or any other site.

261:Y5 PUBLIC MEDIA GATEWAYS

The media gateways shall, as a minimum, support the following:

Analog foreign-exchange-office (FXO) Loop and Ground Start

Ear and mouth (E&M) Basic Rate Interface (BRI) and Primary Rate Interface (PRI) support (NI2, 4ESS, 5ESS, EuroISDN, DMS100, and DMS250)

Caller ID name and number

Automatic number identification (ANI)

Digital trunk support (T1/E1)

Direct inward dialing (DID)

Direct outward dialing

E1 R2 support

Dedicated trunk mapping to phone button

H.323 trunks with H.450 support

H450.12 automatic detection of H.450 support for remote H.323 endpoints

H.323-to-H.323 hairpin call routing for non-H.450-compliant H.323 endpoints

SIP trunks and RFC 2833 support

Transcoding with G.711, G.729a, and iLBC

ECMA/ISO ISDN Q.SIG supplementary services of basic calls, including:

- Call forwarding busy, no answer, all
- Calling line identification presentation (CLIP) and calling name identification presentation (CNIP)

Connected line identification presentation (COLP) and connected name identification presentation (CONP)

Message waiting indicator (MWI) and message center support

MWI passthrough QSIG-to-time-division multiplexing (TDM) voicemail

261:Y6 APPLICATIONS: VOICE MAIL AND UNIFIED MESSAGING SYSTEM

Y610 DESCRIPTION AND SUPPORT OPTIONS: The Contractor shall give a detailed description of his voice mail/unified messaging product offering. Include an overview of the hardware, software, architecture, and components of the equipment to meet the Employer's requirements.

Y620 SPECIFICATIONS

The voice messages shall be stored in an industry standard format.

Once a voice mail is left, the user shall be able to forward it to another user. The user shall also be able to append comments before forwarding the message to another user.

The voice mail / unified messaging system shall be remotely accessible for both subscribers and administrators, e.g. from a standard touch-tone phone or any other types of clients and points of access.

The system shall support analog and/or digital interface ports. If analog, the Contractor shall include the specific interface card required for the IP communication system. If ports are digital, the Contractor shall provide all specifications that the telephone system must meet for proper operation.

Y630 SYSTEM FEATURES

The system shall have a voice digitization technique. The voice digitization rate used for recording users' speech shall be as a minimum 64kbps for G.711 and 8kbps for G.729a.

The system shall provide a notification message that these limits have almost been reached.

The system shall provide an "end of recording" warning and user adjustable playback speed control (with full pitch preservation).

The voice mail system shall support multiple greeting.

The voice mail system shall support a "zero out" to the attendant feature. This feature shall be configurable by class of service. The "zero out" destination could be a station rather than the attendant. The call shall be re-directed if the "zero out" destination is busy, or rings unanswered.

Users should be required to enter a password to access their voice mailbox.

The system shall track failed password entries in a single session. The system shall also automatically disconnect the caller after a configurable number of failed attempts.

The system shall track failed password entries across multiple sessions. The system shall also automatically lock out the user after a configurable number of failed attempts.

The system shall log information about failed password attempts.

The system shall require a system administrator password.

Y640 USER FEATURES

The system subscribers shall be able to conduct as a minimum the following actions:

Pause and replay messages.

Record messages; send and mark “urgent”, “private”, etc.

Transfer messages to other users and append them with their own comments.

Create their own distribution lists.

Edit/Modify their own distribution lists.

Dial internally by name / company directory.

Obtain user instruction through system prompts.

Record personal greetings.

Modify own passwords.

Set business days and hours for alternate greetings.

Y650 SYSTEM ADMINISTRATION: The system administration shall be done through a standard web-enabled GUI which can perform the following actions:

Add or modify a class of service. State what user permissions or characteristics within a class of service can be created or modified.

Set the minimum and maximum password length for a user.

Set the maximum length of voice messages.

Set the maximum failed login attempts before a user lockout from the mailbox.

Assign default passwords for users, and reset passwords for users that have been locked out of their mailboxes.

Set the “disk space remaining” warning level.

Add, delete, or modify a user.

Provide reports concerning storage and call information.

261:Y7 CALL ROUTING AND REPORTING SOFTWARE FUNCTIONALITY

Y710 CALL ROUTING:The system shall manage call routing from a single application. The system shall provide as a minimum the following routing strategies:

Application-based routing and reporting.

Automatic call distribution.

Call-by-call routing.

Call re-routing based on wait time.

Call re-routing based on non-answer.

Conditional routing based on time of day, day of week and holidays.

Conditional routing based on calls in queue.

Conditional routing based on caller origin.

Conditional routing based on dialed number.

Conditional routing based on caller-entered digits (CED).

Directed agent routing (single agent selection).

Database call handling.

Look ahead queuing.

Look back queuing.

Overflow (retains queue position).

Priorities.

Skill-based routing.

Build your own strategy routing.

The system shall provide agent proficiency setup.

All contacts shall be “queued” in the same fashion regardless of media type.

The system shall provide routing priorities.

The software shall provide reports for all agents across all locations.

The software shall collect information through the entire life of the complete Employer interaction and provide not only Real-time , but also historical reporting.

The application shall support a web-view monitoring tool for read-only access to Real-time contact center performance reports and call routing scripts.

The system shall offer the ability for an agent to record a conversation with a customer (for instance if a customer was being abusive).

## 261:Y8 DIAL PLAN AND ADVANCED ROUTING FEATURES

Y810 The Contractor shall be responsible of the system Dial Plan design and configuration and the advanced routing features including, but not limited to, the following:

Amount and type of routing plans.

Type of trunks supported in routing scheme.

Queuing and overflow capabilities.

Use of authorization codes on individual routes.

Handling digit deletion and insertion regarding the North American Dialing Plan.

Route filtering method.

The Contractor shall submit the system Dial Plan structure for approval.

## 261:Y9 COMPUTER TELEPHONY INTEGRATION (CTI)

A. The system shall be able to provide screen-pop integration capability.

B. The system shall be able to access database information for call routing decisions or screen pop data.

C. The system shall be able to deliver third-party call control from a CTI-enabled desktop.

## 261:Y10 EMERGENCY SERVICES

A. The system shall support emergency services. The system shall also be able to redirect callers who dial “911” or “9+911” to a predetermined location, i.e. security desk, operator’s console, etc.

B. Emergency services to eb accounted for shall include, but not be limited to, the following

1. 112 Police
2. 125 Civil Defense
3. 140 Red Cross-Lebanon

4. 175 Fire Departement

5. 1717 General Security

C. The system shall be capable to provide location information of the IP phone and makes a 911 call.

D. The system shall provide Voice Recording functions associated with emergency and hot line services.

261:Y11 SYSTEM ADMINISTRATION REQUIREMENTS

Y1110 SYSTEM ADMINISTRATION TOOL(s) shall be available to meet the following requirements:

The system administration application shall be accessible from any workstation on the LAN / WAN.

The system administration application shall be accessible through a standard web browser.

The administration tool(s) shall have security features to prevent unauthorized access to the administration application. A minimum of four security levels shall be defined. Permission levels shall be customizable and cannot be set to a certain limit.

The administrative application system shall have an alternate form of access if the primary access is unavailable.

The administrative application shall have on-line help.

261:Y12 SYSTEM MONITORING AND DIAGNOSTICS

Y1210 DIAGNOSTIC TOOLS: The system shall have diagnostic tools that support the Windows NT type Event Log. These diagnostic tools shall be able to produce diagnostic reports to aid in isolating faults. The diagnostic tools shall be remotely accessed and SNMP compliant.

Y1220 REMOTE DIAGNOSTICS should be supported. The administrators shall be able to see and access any alarms or alerts on the system from remote terminals.

Y1230 MONITORING REPORTS: The system shall be capable to produce monitoring report(s) including but not limited to the following:

Performance monitoring.

Quality monitoring.

Events monitoring.

Y1240 MONITORING TOOLS:The system shall support the system monitoring items listed below:

Trunking status.

Real-time traffic.

Status of all routing components.

Status of all remote components.

Status of individual stations.

Status of gateway ports.

Provide call trace capability.

Monitor for Toll Fraud.

Telephone system analysis.

Y1250 The system shall provide system alarms and alarm notifications from the IP call-processing unit.

261:Y13 SYSTEM REPORTING AND CALL DETAIL REPORTING

Y1310 CALL DETAIL REPORTING: IP-based Telephony Communications System shall have a CDR reporting applications. The following minimum standard reporting capabilities shall be available:

E. Directory Number Allocation.

F. Trace Log Files.

G. Real-time Monitoring.

261:Y14 CONSTRUCTION

Y1410 CABINET: exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet, with lockable front access doors, and whole assembly is to fit into one integrated form. Cabinet is to be dust and insect proof, and ventilation is to be provided as required for specified ambient conditions and air-conditioning facilities. Range of temperatures recommended for continuous operation of the system are to be submitted to the Engineer.

Y1420 PLUG-IN EQUIPMENT: electronic circuits and components are to be plug-in card type, with solid state electronic components. Equipment is to be assembled neatly in racks. Sensitive equipment is to have dust protection covers.

## FIELD AND INSTALLATION WORK

### 261:1 DESIGN

A. The design of the IP-based Telephony Communications System shall consist of the following tasks:

1. Needs Analysis - The Contractor shall work with the Employer's Representatives, departments, tenants and any other company or organization and determine their exact requirements for IP-based Telephony Communications Services.

2. Engineering and Design - With the information gathered the Contractor should determine hardware and software requirements for the Employer's IP-based Telephony Communications System. This shall include the quantities and configuration of the system components and the configuration of the Network Management System. The configuration shall include IP telephony addressing plan, etc.

3. The Contractor shall determine the exact requirements for external communications and interfacing if it is determined that such services will be required for the support of the new systems.

4. The Contractor shall coordinate with the other disciplines to ensure that environmental requirements for the IP-based Telephony Communications System are met, and to ensure that cabling is installed at the locations specified during the needs analysis.

### 261:2 PROJECT MANAGEMENT

A. The Contractor is required to supply a complete description (Project Plan) of the key activities required for the installation of the system.

B. In the project plan, the Contractor shall include a project organization chart with the reporting relationships of project team members and other key personnel. An escalation matrix should also be included.

C. It is essential that the installation of the new system be as transparent as possible to the users. There should be no telephone service interruptions, no interim changes in dialing procedures, and no perceived degradation in the quality of service.

D. A master project schedule must be included, along with a work responsibility matrix, identifying the tasks the Contractor will perform and the tasks the Employer is expected to perform to successfully implement the new system.

## 261:3 FACILITY REQUIREMENTS

A. The Contractor shall furnish all space, power, and environmental requirements for the system.

1. Space - Provide the physical dimensions of the equipment.

2. Power - All power requirements, including any special conditioning or grounding requirements.

3. Heat - The Contractor must provide heat dissipation calculations for the communication room(s) and the recommended safe temperature operating range for the system.

4. Floor Loading - The Contractor must provide complete floor loading requirements.

## 261:4 INSTALLATION

A. The Contractor is solely responsible for the complete turn-key engineering of the new IP-based Telephony Communications System and all interconnecting facilities.

B. Acceptance of works will be restricted to the equipment and installations complying with the approved submittals, approved shop drawings, and the Employer’s Representative’s agreement.

C. The Contractor shall perform station reviews, database preparation, and original program initializations.

D. The Contractor shall install, configure and test the components of the IP-based Telephony Communications System including the Network Management System.

E. The Contractor has to carry out any site works under direct supervision of qualified technicians who are to be well trained with qualified Manufacturer experience.

F. The Contractor shall complete the required data circuits from the system to the end-user station.

G. The Contractor shall coordinate the ordering of all long-distance and local communications facilities and services as deemed necessary by the Employer. Ensure that WAN circuits are in place as required. After services have been provided, the Contractor shall test the services to ensure functionality.

H. Cabling made by the Contractor shall account for redundancy, disaster recovery, and protection against single points of failure.

I. The system shall comply as a minimum with standard Ethernet distance limitations.

J. Site workmanship of any network component has to be limited to the layout and fixation, and inter-wiring of various items of the ready-made equipment.

K. In addition to the above, the Contractor is also expected to supply the following:

1. Coordination meetings with the Project authorities, the Employer's departments, operators, existing contractors, etc.

2. Progress reports and Progress reviews,

3. Insurance for the Transport of the equipment,

4. Quality Assurance setup and management,

5. Document Management,

6. Configuration Management for the duration of the Project,

7. Off-the-shelf Software updates for the duration of the warranty,

8. User documentation and training including textbooks,

9. Worksite expenses (Setup and removal of temporary offices, Worksite vehicles, Site Offices, Computers, Printers, Desks, etc.),

10. Archival.

## 261:5 FIELD QUALITY CONTROL

A. The Contractor shall submit to the Employer the manufacturing and shipment schedules for all equipment and/or materials at least one month prior to the time of packing for shipment as long as the lead time available is sufficient or such shorter period as may fit the actual circumstances. Should the Employer's representatives fail to attend on the specified date for inspection, the Contractor shall proceed with shipment and carry out the relevant tests itself. The Contractor shall provide the Employer a copy of the recorded factory results made under its cognizance before shipment. If the test results show that the equipment and/or materials do not comply with the Specifications, such non-complying equipment and/or materials shall be rejected and shall not be shipped until repaired or replaced and tested again. In such case, the Contractor shall be held liable for any resulting delay. In all cases, the Contractor shall be responsible for the compliance of his equipment and materials with the Contract's specifications.

B. Testing: On installation of system components, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.

C. Correct malfunctioning units at Project site, where possible, and retest to demonstrate compliance; otherwise, remove and replace with new units and retest.

## 261:6 COMPLETION SERVICES

A. The Contractor shall initiate system operation. The Contractor shall provide competent start-up personnel on each consecutive working day until the system is fully functional and ready to start the acceptance test phase.

B. Preparation for acceptance (prior to final inspection):

1. Temporary and old systems, facilities and utilities shall be properly disconnected, removed and disposed of off-site.

2. All systems, equipment and devices shall be in full and proper adjustment and operation, and properly labeled and identified.

3. All materials shall be neat, clean and unmarred and parts securely attached.

4. Test reports of each system component shall be complete and available for inspection and delivery as directed by the Employer's Representative.

C. System acceptance requirements: Before final acceptance of work, the Contractor shall deliver six (6) composite "Systems Operation and Maintenance" manuals in three-ring binders, sized to hold the material below, plus 50% excess. Each manual shall contain, but not be limited to:

1. A Statement of Guarantee including date of termination and the name and phone number of the person to be called in the event of equipment failure.

2. A set of operational procedures for the overall system that includes all required activities and that allows for Employer's operation of all system capabilities. This procedure shall fully address all Employer's established system operating objectives.

3. Individual factory-issued manuals, containing all technical information on each piece of equipment installed. In the event such manuals cannot be obtained from a manufacturer, it shall be the responsibility of the Contractor to compile and include them. Advertising brochures shall not be used in lieu of the required technical manuals and information. All manuals shall be printed to ensure their permanence. No "blue-line" type of reproduction is acceptable.

## 261:7 FACTORY TESTS

A. Factory Acceptance Tests

1. The Factory Acceptance Tests shall be carried out in a hardware and software environment, which simulates the final configuration of the system.

2. The Contractor shall carry out any Factory Acceptances Tests, in Manufacturer's factory itself, before any site delivery, in order to show to the Employer's Representative that the system of both hardware and software and the system after integration of various sub-systems is able to satisfy site technical requirements of the equipment specifications.

3. Some of the functional or performance tests, which cannot be conducted in a simulated environment, due to their nature and complications, may subject to the Employer's Representative's approval be combined with the On-site Tests.

4. All travels and trips costs shall be provided by the Contractor for five (5) representatives to be nominated by the Employer.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.

2. The tests are to cover every aspect related to the specification of the system and its operation; including, but not limited to, visual inspections, measurements, and operation.

3. All Factory Acceptance Tests need to be carried out in the presence of the Employer's Representative unless otherwise agreed by the Employer's Representative. The Employer's Representative will sign off the testing document on satisfactory completion of the tests.

4. All Factory Acceptance Test Specifications, at every level, shall be subject to configuration management and change control by the Contractor.

5. The results of the Factory Acceptance Tests, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

C. Equipment Tests

1. Equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Employer's Representative before dispatch of equipment to site.

## 261:8 ON-SITE TESTS AND INSPECTION

A. On-site Assembly Verification

1. The purpose of this phase is to check the assembly and the connection of the equipment without any power supply.

2. Any verification can give raise to a punch list item either because of an anomaly or a none-conformity with the tender documents.

3. The punch lists are collated for each module and the phase report is only released when all the stipulations on the punch lists are cleared.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.

2. The tests are to cover every aspect related to the specification of the system and its operation including, but not limited to, visual inspections, measurements, and operation.

C. On-site Cable Tests

1. Cables are to be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling in and laying.

D. Inspection

1. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

E. Pre-Testing

1. Align and adjust system and perform pre-testing of all components, wiring, and functions to verify compliance with specified requirements.

2. Correct all deficiencies by replacing malfunctioning or damaged items with new items.

F. Manufacturer's Field Services

1. Engage a factory authorized service representative to inspect field assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming.

2. Report results in writing.

G. Procedure

1. Notify the Employer's Representative not less than 30 days in advance, of proposed schedule, procedures and tests to be used in operational testing.

2. Conduct operational tests only with the Employer's Representative present.

H. Report

1. Prepare a written report of observations, inspections, tests, and results, including:

   a. A complete listing of every device and circuit,
   b. Date of each test and retest, and by whom,
   c. Results of each test and, if failure occurred, corrective action taken prior to retest.

I. Certification

1. The Contract shall certify that all devices, circuits, and total system are finally tested successfully.

J. Operational Tests

1. Schedule tests after pre-testing has been successfully completed.

2. Perform operational system tests to verify compliance with Specifications.

3. Test all modes of system operation including:

   a. Functional operation of each field mounted device,
   b. Functional operation of each control circuit,
   c. Supervision function of each initiating, indicating, monitoring, and control circuit,
   d. Perform tests that include originating program and counting material at final outlets, controller inputs, and other inputs,
   e. Signal Ground Test: Measure and report ground resistance at each global equipment pin.
   f. Re-testing: Correct deficiencies, and re-test. Prepare written record tests.
   g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

4. Schedule tests with at least seven days advance notice of test performance.

K. Integrated Tests with Other Contractors

1. The Contractor shall make equipment available for testing and demonstrating various features specified.

2. The test procedures shall reflect the sequence of tests to be performed.

3. Retesting: Correct deficiencies and retest until total system meets requirements of the Specifications and complies with applicable standards. Prepare written records of tests.

4. Schedule testing with at least seven days advance notice.

261:9 TRAINING

A. The Contractor is required to conduct end-user training on the Employer's premises, tailored specifically to the Employer's particular requirements (e.g., console operator, message center operator, secretary, and professional) in the use, configuration and maintenance of the IP telephony equipment.

B. Training shall be provided for Technical Staff of the Employer in the Testing, Maintenance and Fault Location of the IP-based Telephony Communications System.

C. For each product and/or application, the Contractor shall provide a detailed description of the training the Manufacturer will provide.

D. Trainers

1. All training shall be certified training by Manufacturer and trainers shall be approved by the Employer before starting.

2. Engage a factory authorized service representative to explain programming and operation of system and to train Employer's personnel on procedures and schedules for maintaining, programming, operating, adjusting, troubleshooting, and servicing the system.

E. Training Program

1. Scope

a. Training shall be in sufficient scope to ensure that all trainees who complete the program will be certified as capable to operate and/or maintain the equipment, systems, and facilities provided and installed under this Contract, and to ensure a smooth transition between construction and operations activities.

2. Language

a. Training shall be conducted in English and Arabic.

3. Training Aids

a. Training aids shall include:

1) Approved Operation and Maintenance (O&M) manual(s) prepared by the Contractor as part of this Contract,
2) Training manuals, including course outline, basic text of instructions modules, and trainee workbook,
3) Films, slides, video tape(s),
4) Charts, models, hand-outs, catalogues,
5) Samples and other visual,
6) Written aids to complement instruction.

b. In addition, spare parts and other special hardware shall be provided to support “hands-on” familiarization with the equipment or systems.

4. Training Manuals

a. Training manuals shall be provided for each training course covering both the classroom and on-the-job phases.
b. The organization of the manuals shall follow the same sequence as the course’s scheduled presentation of material, providing such additional background and supplementary information, as a trainee may need to understand the O&M manuals.
c. There shall be as many Training Manual types as Trainees categories.

5. Training Execution

a. Scope

1) Training shall be performed in accordance with an approved training program. All training aids shall be available and approved prior to start of training.

b. Contents

1) Training course can be broken down into modules either classroom lecture or ‘On-the-job’ training.
2) In case of lecture, it is the Employer responsibility to provide the classroom for the duration of the course.
3) No lecture module should exceed 2 hours time.
4) “On-the-job” training can be scheduled for entire 8 hour shift.
5) Handouts must support each module; the collation of the Handouts forms the Training Manual.
6) Laboratory equipment, spare parts, and mock-up models may be used for theoretical orientation.
7) However, practical “hands-on” familiarization shall be provided on equipment that is either installed and operable or ready to be installed and capable of being operated. System spares of special hardware items may be used to support “hands-on” familiarization as long as said spares are returned to inventory in satisfactory condition in accordance with approved procedures.

c. Proficiency

1) At designated intervals each trainee's proficiency levels shall be determined by written, oral and practical performance tests.

d. Operations Training

1) Operators shall be provided with a thorough training in all aspects of system/sub-system operation under both normal and abnormal conditions. This training shall include, but not be limited to:

a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
b) Terminology,
c) Operations theory and interface,
d) Equipment appearance, functions, concepts and operations,
e) Operating mode, practices, and procedures under normal and emergency conditions,
f) Safety precautions,
g) On-the-job operating experience covering all system/sub-system operating functions, activities, and tasks including those associated with degraded operating modes, failure recognition, and recovery processes,
h) Familiarity with content and use of O&M manuals and related reference publications.

e. Maintenance Training

1) Maintenance training shall cover all on-site routine, preventive, and remedial maintenance of the system/sub-system.
2) This training shall include, but not be limited to:

a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
b) Terminology,
c) Operations theory and interfaces,
d) Equipment appearance, layout, functions, concepts and operations,
e) Operating modes, practice, and procedures under normal and emergency conditions,
f) Safety precautions,
g) Use of tools and test equipment,
h) Use of system utilities, diagnostic software and various software tools associated with the system maintenance,
i) Preventive maintenance,
j) Troubleshooting, diagnostics, and testing,
k) Backup and restoration of software/configuration,
l) Assembly and disassembly,

m) Repair and parts replacement,
n) Parts ordering practices and storage,
o) Failure and recovery procedures,
p) System/sub-system cabling,
q) Familiarization with and use of O&M manuals and other reference materials.

f. Administrator Training

1) Administrator course shall be provided so the system administration staff will be able to:

a) Configure the IP-based Telephony Communications System equipment and the access of all the users,
b) Identify and remedy software faults,
c) Upgrade and implement data and software changes,
d) Production of revised or new displays.

2) This training shall include, but not be limited to:

a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
b) Terminology,
c) Operations theory and interfaces,
d) Software design and organization,
e) Database structure, generation, and modification,
f) Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules,
g) Interface software design,
h) Configuration management and control of software,
i) Backup and restoration of software,
j) Use of system utilities, diagnostic software and various software tools associated with the design, development, and maintenance of the System,
k) Familiarization with and use of O&M manuals and other reference materials.

## 261:10 MANAGEMENT AND WARRANTY

A. The IP telephony system and all associated equipment in the Contractor's solution shall be warranted by the Contractor and by the Manufacturer to be free of defects in equipment, software, and workmanship for a period of at least two years from the date of Substantial Completion.

B. During the warranty period and any subsequent maintenance agreement, any defective components shall be repaired or replaced at no cost to the Employer.

C. All system maintenance during the warranty period and under any subsequent maintenance agreements shall be performed by the Contractor organization using personnel employed full time by the Contractor and at no additional cost to the Employer other than those charges stipulated to maintain the warranty.

261:11 LOGISTICAL SUPPORT

A. The Contractor shall identify the address of the Manufacturer's local service centers and the number of service personnel trained on the system.

261:12 REPAIR RESPONSE

A. The Contractor shall provide routine system monitoring to assure the continued operation of all system components.

B. During the warranty period, the Contractor must supply no more than a 1-hour response to major problems, 24 hours a day, 7 days a week.

# 265 DATA NETWORK INSTALLATION

## 265: A: GENERAL

A101 GENERALLY: work generally is to be in accordance with the requirements of sections 201, 202 and 203 of the specifications.

A105 SCOPE OF WORK: is to include complete data network including, but not necessarily limited to the following:

Installation of a structured wiring system based upon a star topology to connect all manner of applications covering data transmission, including, but not limited to the following:

Communication cabinet (CC) housing cross connection terminal blocks and patch panels

Conduits and raceways.

Wiring and cabling (copper and optical fiber)

Patch cables and jumpers

Voice and data outlets

Ancillary equipment

A201 REGULATIONS AND STANDARDS:

A. Rules

1. The supply shall be conformed to requirements of referenced industry standards, applicable sections.

2. The supply shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.

B. Standards

1. System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC)

a. ISO/IEC 11801: latest edition regarding Information Technology and Generic Cabling for Customer Premise.
b. ISO 14443 A or B Standard.
c. EIA/TIA 568, Commercial Building for Telecommunication Wiring Standard.
d. EIA/TIA 569, Commercial Building for Telecommunication Pathways and Spaces.
e. EIA/TIA 606 for Telecommunications Infrastructure: This document provides the user of this document with guidelines and choices of classes of administration for maintaining telecommunications infrastructure.
f. EIA/TIA 607 Commercial Building Grounding (Earthling) and Bonding Requirements for Telecommunications (ANSI/J-STD-607-A-2002).
g. IEC 60754-1 & 2 Test on Gases Evolved During Combustion of Materials from Cables and Test on Gases Evolved During Combustion of Electric Cables.
h. IEC 61034-1 & 2 Test and Measurement of Smoke Density of Cables Burning under Defined Conditions.
i. IEC 60331 Part 11& 12, Tests for Electric Cables under Fire Conditions.
j. IEC 60332 Tests on Electric Cables under Fire Conditions.
k. IEC 60364-1 Electrical Installations of Buildings, Fundamental Principles, Assessment of General Characteristics, Definitions.

2. IEEE: Institute of Electrical and Electronics Engineers

   a. Comply with the latest issues of material and test standards which have been developed and published by the Institute of Electrical and Electronics Engineers (IEEE) 802 Working Group (WG) data communications.

3. ISO: International Standardization Organization:

   a. It promotes the development of international standardization with scientific, technological and economic activities.
   b. The Technical Committee 97, Information Processing, developed a seven-layer communications reference model that allows multiple protocol and multiple vendor environments to interconnect and operate with one another.

4. Comply, as often as possible, with both ITU-T (International Telecommunications Union) recommendations and US standards. When standards are not compatible in both Europe and US (e.g. telecom interfaces SDH STMx vs. SONET OCx) detailed compatibility and interface availability shall be provided.

5. Building Industry Consulting Service International (BICSI):

    a. Publishes the Telecommunications Distribution Methods Manual (TDMM), which is a comprehensive collection of accepted practices in the design and methodology of communications systems. BICSI provides a competency examination for the professional designation as a registered Communications Distribution Designer.
    b. This manual should be used as a reference only.

6. Network Equipment Building System (NEBS):

    a. Level 1, Level 2, and Level 3 are applicable to these section.

C. Precautions:

1. The above list is a partial list issued from standard organization. Additional consideration may be required to provide protection of communications equipments, data processing equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

A301 EQUIPMENT DATA: submit data for approval including complete technical data and manufacturer's catalogues for all equipment and materials with sufficient description of components and operating parameters.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Detailed system schematic diagram

Detailed layout of all equipment in rooms & closets including elevations

Exact routing and layout of all cabling and wireways

Typical installation details of cabinet(s), boxes, and other equipment.

A801 APPROVED MANUFACTURERS: obtain equipment from one of the following:

| | |
|---|---|
| Cisco | (U.S.A.) |
| Juniper | (U.S.A.) |
| Nortel Networks | (U.S.A.) |
| HP | (U.S.A.) |

Or other equal and approved.

PRODUCTS AND SYSTEMS

265:X SYSTEM ARCHITECTURE

265:X1 GENERAL

X110 GENERAL: system will be based on a star topology. The star topology where separate wiring systems will run in parallel and serve all the project for the transmission of data over a local area network (LAN).

265:X2 DATA NETWORK DISTRIBUTION COMPONENTS

X215 COMMUNICATION CABINET (CC) is to be for termination of horizontal and/or backbone cable distribution. Communication cabinet is to include cross-connection of horizontal and backbone cable terminating using jumpers or patch cards and to allow for flexible connectivity when extending various services to data outlets.

Cabinet is to provide a control environment to house equipment, connecting hardware and splice closures. Communication cabinet is to be equipped with patch cards and panels, connectors, cross-connect blocks, etc, and have the following functions:

- To contain the network termination point.
- To contain the backbone to horizontal wiring connections.
- To contain the inter backbone connections.

X220 BACKBONE (FEEDER) CABLING is to be provided by one or more of the following types of cables that extend to each closet.

1. A multi-pair data copper cable.

2. A multimode 50/125μm optical fiber cable. This cable shall consist of 4 core fibers.

3. A singlemode 9/125μm optical fiber cable. This cable shall consist of 2 to 48 core fibers.

In the communication cabinet, the connection between horizontal cabling and backbone cabling shall take place.

X225 COPPER CABLES are to be 4 unshielded twisted pairs of 24 AWG thermoplastic insulated solid conductions and enclosed by a thermoplastic jacket. UTP cables shall have a characteristic impedance of 100 ohm +/- 15% in the frequency range of 1 MHz up to the highest measured frequency and dc resistance of any conductor not exceed 9.38 ohm per 100 meter at or corrected to a temperature of 20°C. Cables are to be Cat 6.

X230 THE FIBRE BACKBONE should be accordance with the following performance specifications.

Multimode optical fiber cables shall have the following specifications:

Fiber size: 50/125μm multimode graded index ITU-T G.651.1 compliant

Type: tight buffered, plenum rated, non conductive optical fiber (OFNP)

Jacket: outer and subunit jackets-FCP (fluorocopolymer)

Max. Attenuation: 3.5/1.0 dB / km at 850/1300 nm respectively.

Min. modal bandwidth: 500/500 MHz·km at 850/1300 nm respectively.

Singlemode optical fiber cables shall have the following specifications:

Fiber size: 9/125μm singlemode ITU-T G.652.D compliant

Type: loose tube, non-metallic, jelly filled with central strength member

Outer sheath: black polyethylene

Max. Attenuation: 0.38/0.25 dB / km at 1310/1550 nm respectively.

Max. Zero dispersion slope: 0.092 ps / ($nm^2$·km)

Max. Dispersion coefficient: 3.5/18 ps / (nm·km) at 1310/1550 nm respectively

Fiber cables shall be terminated on fiber optic patch panels to facilitate moves and changes. Fiber optic patch panels shall provide connectivity with LC type fiber connectors.

X235 HORIZONTAL CABLING is to extend from the CC to the work area information (data/voice) outlet. It includes cross connects in the CC, the horizontal cable and the outlet.

X240 HORIZONTAL CABLES shall connect the work area outlet to the cross connect system in the CC. Cables shall be unshielded twisted pair (UTP). Each cable shall be formed of four pairs category 6 low-smoke zero halogen (LSZH) rated to ANSI/TIA 568-C.

X250 CROSS-CONNECT HARDWARE is to terminate the horizontal cable, backbone cable and equipment in the CC.

X255 DATA OUTLET is to have a modular grid box and cover plate similar to devices as described in Section 241 of the specifications. Jacks are to be modular 8 - position RJ45. Generally a gang box with minimum two RJ45 jacks shall be used throughout the work areas.

X160 CONDUITS AND RACEWAYS are to be provided in accordance with section 218 of the specification.

X265 EARTHING: provide interference free earthing to protect personnel and equipment from hazardous voltages and to reduce EMI to and from the data network.

265:X3 WIRE CROSS-CONNECT HARDWARE

X310 DESCRIPTION: the Connector System is to be used to terminate and interconnect cables and to route circuits throughout the distribution system.

X335 THE PATCH PANEL SYSTEM: typically used with high speed applications because patch cords are needed for circuit termination. They are to be equipped with 12, 36 and 48 - 8 position modular jacks. Patch panels will be provided with factory assembled Cat 6 patch leads for each information point. Patch leads will be colored separately for voice and data.

X345 PATCH CABLES & JUMPERS are to connect the cross-connect hardware in the CC.

FIELD AND INSTALLATION WORK

265:1 INSTALLATION

1101 EQUIPMENT INSTALLATION ON SITE is to be limited to fixation and inter-wiring of various items of the readymade equipment.

1201 CABLES are to be run concealed in underground ducts on cable trays/trunks, in conduits above suspended ceilings, in walls or under raised floors in a manner to protect them from physical damage and excessive heat, and to permit ease of accessibility for servicing and modifications. Fixing accessories are to include two- piece plastic clamps, galvanized screws, wall base-holders and fibber-plastic inserts or bolts, subject to the approval of the Engineer.

1301 CONDUITS AND RACEWAYS: are to be provided in accordance with Section 218 of the Specification.

1501 EARTHING: provide interference-free earthing as necessary in accordance with Section 219 of the Specification.

1601 TOOLS: use only proper tools for all installation work particularly in making connections.

1701 SUPERINTENDANCE: carry out installations under the direct supervision of a qualified technician, licensed by and trained at the factory.

1851 ALL CABLES will be clearly indentified and labeled at both ends. Individual fibers in an optical fiber cable will be color coded for identification. The cables will be imprinted with fiber count and aggregate length at regular intervals.

## 265:2 TESTS

2101 EQUIPMENT AND LABOUR: provide equipment and labor for site testing of all items of system.

2111 SITE TESTING: prior to system hand-over, it is to be demonstrated to the satisfaction of the Engineer that installed equipment meets the requirements of the Specification and is ready for hand-over. All wiring is to be verified to Category 6, 100 Mbps or better using “Microtest Penta Scanner” or other approved equal testing machine.

2110 Tests: To assure a high degree of reliability and performance of the transmission, the following test parameter is to be checked after completion of installation comprising attenuation, NEXT Loss, return Loss, and DC Resistance.

## 265:3 MISCELLANEOUS ITEMS

3310 SPARE PARTS AND TOOL KITS are to be provided as per the manufacturer’s recommendations for IDC connection modules, cable management, patch panels, racks & cabinets, data outlets, board extractors, cleaning kits, test stations, digital multi-meter and battery testing kit.

3325 TRAINING of personnel is to be carried out during the experimental period. Training of operation and maintenance staff is to be carried out separately. One hour sessions are to be provided for end users. Contractor is to prepare a schedule one month prior to experimental period and submitted to Consultant for approval.

3330 GUARANTEE AND WARRANTY: during the experimental period, the system is to be operating under the Contractor's supervision and responsibility. After the satisfactory completion of this period, the system is to be handed over to client whereby the two year warranty is to start.

## 265:4 DOCUMENTATION

4401 CABLE SYSTEM: is to be fully documented to include.

a) Cable records showing unique individual numbering of cables.

b) Cable size and routing information.

c) Patch panel numbering and labeling.

d) Patching records.

e) Wall jack records

All cables are to be marked and identified both at the terminating ends and at regular intervals along the length of the cable. The method of marking used shall be secure, legible and not subject to fading.

# 266 ACTIVE COMMUNICATION AND DATA PROCESSING EQUIPMENT

## 266: A GENERAL

A101 GENERALLY: work generally is to be in accordance with the requirements of sections 201, 202 and 203 of the specifications.

A105 SCOPE OF WORK: is to include complete data network including, but not necessarily limited to the following:

installation of a data communication and processing system based upon an IP networking communication technology to connect all manner of applications covering data transmission, switching, routing, including, but not limited to the following:

Routers,

Core Switches,

Access/Edge Switches,

Gateways for connection to the national network..

A151 DEFINITIONS

ACL: Access Control List.

BGP: Border Gateway Protocol.

CLI: Command Line Interface.

CoS: Class of Service.

CRTP: Compressed Real Time Protocol.

DBR: Deterministic Bit Rate.

EMI: Electromagnetic Interference.

EN: European Standard.

FCC: Federal Communications Commission.

FDM: Frequency Division Multiplexing.

FTP: Foiled Twisted Pair.

GTI: Global Time of Intervention.

GTR: Global Time of Restoration.

GUI: Graphical User Interface.

IEC: International Electro-technical Commission.

IP: Internet Protocol.

IS-IS: Intermediate System-Intermediate System.

ISO: International Standard Organization.

ITU-T: ITU Telecommunication Standardization Sector.

LAN: Local Area Network.

MPLS: Multi-Protocol Label Switching.

MTTR: Mean Time To Repair.

MTBF: Mean Time Between Failures.

NFPA: National Fire Protection Association.

OSPF: Open Shortest Path First.

PSTN: Public Switched Telephone Network.

QoS: Quality of Service.

RSVP-TE: Reservation Protocol for Traffic Engineering.

SBR: Statistical Bit Rate.

SCN: Structured Cabling Network.

SLA: Service Level Agreement.

SNMP: Simple Network Management Protocol.

STM: Synchronous Transport Module.

STP: Shielded Twisted Pair

TDM: Time Division Multiplexing.

UL: Underwriters Laboratories.

UPS: Uninterrupted Power System.

UTP: Unshielded Twisted Pair.

VLAN: Virtual LAN.

VPN: Virtual Private Network.

WAN: Wide Area Network.

WWW: World Wide Web.

## A201 REGULATIONS AND STANDARDS:

A. Rules

1. The supply shall be conformed to requirements of referenced industry standards, applicable sections.

2. The supply shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.

B. Standards

1. System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC)

   a. ISO/IEC 11801: latest edition regarding Information Technology and Generic Cabling for Customer Premise.
   b. ISO 14443 A or B Standard.
   c. EIA/TIA 568, Commercial Building for Telecommunication Wiring Standard.
   d. EIA/TIA 569, Commercial Building for Telecommunication Pathways and Spaces.
   e. EIA/TIA 606 for Telecommunications Infrastructure: This document provides the user of this document with guidelines and choices of classes of administration for maintaining telecommunications infrastructure.
   f. EIA/TIA 607 Commercial Building Grounding (Earthling) and Bonding Requirements for Telecommunications (ANSI/J-STD-607-A-2002).
   g. IEC 60754-1 & 2 Test on Gases Evolved During Combustion of Materials from Cables and Test on Gases Evolved During Combustion of Electric Cables.

h. IEC 61034-1 & 2 Test and Measurement of Smoke Density of Cables Burning under Defined Conditions.
i. IEC 60331 Part 11& 12, Tests for Electric Cables under Fire Conditions.
j. IEC 60332 Tests on Electric Cables under Fire Conditions.
k. IEC 60364-1 Electrical Installations of Buildings, Fundamental Principles, Assessment of General Characteristics, Definitions.

2. IEEE: Institute of Electrical and Electronics Engineers

   a. Comply with the latest issues of material and test standards which have been developed and published by the Institute of Electrical and Electronics Engineers (IEEE) 802 Working Group (WG) data communications.

3. ISO: International Standardization Organization:

   a. It promotes the development of international standardization with scientific, technological and economic activities.
   b. The Technical Committee 97, Information Processing, developed a seven-layer communications reference model that allows multiple protocol and multiple vendor environments to interconnect and operate with one another.

4. Comply, as often as possible, with both ITU-T (International Telecommunications Union) recommendations and US standards. When standards are not compatible in both Europe and US (e.g. telecom interfaces SDH STMx vs. SONET OCx) detailed compatibility and interface availability shall be provided.

5. Building Industry Consulting Service International (BICSI):

   a. Publishes the Telecommunications Distribution Methods Manual (TDMM), which is a comprehensive collection of accepted practices in the design and methodology of communications systems. BICSI provides a competency examination for the professional designation as a registered Communications Distribution Designer.
   b. This manual should be used as a reference only.

6. Network Equipment Building System (NEBS):

   a. Level 1, Level 2, and Level 3 are applicable to this section.

C. Precautions:

1. The above list is a partial list issued from standard organization. Additional consideration may be required to provide protection of communications equipments, data processing equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

A301 EQUIPMENT DATA: submit data for approval including complete technical data and manufacturer's catalogues for all equipment and materials with sufficient description of components and operating parameters.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Layout of network components, network management system, etc.

System labeling schedules, including electronic copy of labeling schedules in software and format selected by the Owner Representative.

Complete electrical and physical characteristics of network components, network management system, etc.

Complete system wiring diagrams, size and type of cables, enclosures, and terminal, splice boxes etc., and routing plans of wiring system.

Include dimensioned plan and elevation views of components. Show access and workspace requirements.

A801 APPROVED MANUFACTURERS: obtain equipment from one of the following:

Cisco (U.S.A.)

Alcatel-Lucent (U.S.A.)

Nortel Networks (U.S.A.)

Juniper (U.S.A.)

HP (U.S.A.)

or other equal and approved.

A901 NETWORK REDUNDANCY, RELIABILITY AND AVAILABILITY

Network design should be made to assure real time failure recovery. This is the reason why redundancy, reliability, and availability are wished throughout the network using load balancing mechanisms and clustering techniques.

As most Manufacturers have implemented proprietary optimizations for such purposes, detailed information on system performance shall be given.

A902 NETWORK PERFORMANCE AND QUALITY OF SERVICE

Performance and Quality of Service (QoS) should be maintained throughout the data network using, but not limited to, efficient queuing, scheduling, shaping and policing. In addition, the effective use of these tools allows effective allocation and management of the bandwidth to meet the needs of different users and applications.

The solution should support intelligent network resiliency, signaling and routing protocols. Strategic implementation of redundancies and diversity to avoid single point of failures is also a key design consideration.

A test plan for performance in operations shall be proposed by the Contractor and, after Employer's agreement, implemented as one of the global acceptance tests.

A903 NETWORK SECURITY

Network security should be inherent/built-in by design and available at different and all levels of the network. Steps for securing the network and providing reliable operations are, but not limited to:

Physical Access: Limit and track physical access to all network and server elements.

Virtual Access: Limit, authenticate and track access to every network device and server.

Logical Network Separation: Create subnet boundaries between user data networks, server farm, IP Telephony, etc.

Virus Scanning and Host Security: Use a comprehensive virus scanning and server/application security policy.

PRODUCTS AND SYSTEMS

266:X SYSTEM ARCHITECTURE

266:X1 GENERAL

X101 GENERAL: The system architecture shall support multi-manufacturer interoperability with other manufacturer's products and across any QoS infrastructure.

The system architecture shall support end-to-end QoS, low latency queuing, link efficiency and traffic shaping.

The Data Network active infrastructure shall be highly scalable, growing from a small amount of users, to thousands of users, with the potential to further expand. Although implemented initially for data communications, the infrastructure shall be capable of multiple means of real time communication (voice, video, instant messaging, collaboration, etc.). The infrastructure shall provide high availability, redundancy, and contingency. The infrastructure shall be able to integrate with many other devices and applications, from existing voice infrastructure to new endpoints and applications.

## 266:X2 ACTIVE DATA NETWORK PROCESSING COMPONENTS

### X201 CORE SYSTEM REQUIREMENTS:

A. Mounting:

1. All equipment shall be rack-mountable.

B. Required Topology:

1. Reliability of solution shall demonstrate equivalent performance such as 800 ms recovery or better.

C. Switch Fabric Capacity: Minimum 128 Gbps.

D. Packet per Second Forwarding Rate: Minimum 17 Mpps.

E. Supported Protocols and Standards (as a minimum):

1. Ethernet:

a. IEEE 802.3z

b. IEEE 802.3ab

2. Internet Protocol:

a. IPv4

b. System should be IPv6 ready.

3. Routing Protocols: (at least one of the following)

a. Intermediate System-to-Intermediate System (IS-IS),

b. Open Shortest Path First (OSPF) v2.0,

c. Routing Information Protocol version 2 (RIPv2) with RIP next generation (RIPng).

F. Management Controls: CLI, SNMP.

G. Supported Interfaces:

1. Small Form-factor Pluggable (SFP)

H. Number of Ports Required:

1. Core switch ports following the requirements and guidelines as described in the design section and the referenced Sections of this Specification.

2. The Contractor shall account for 25% additional port capacity to accommodate for future growth and expansion.

I. Traffic Management: The following features shall be supported as a minimum:

1. L2, L3 Classifications.

2. IP ToS and 802.1p.

3. Policing mechanism.

4. Policing parameters.

5. Policing enforcement points (egress & ingress).

6. Policing traffic classification, policing actions.

7. Traffic shaping.

8. Queue congestion

a. Round Robin,

b. Weighted Fair Queuing,

c. Priority Queuing.

9. Configurable queue congestion threshold.

J. Scheduling:

1. Queues for Gigabit ports, queues traffic assignment.

K. VLAN Support (as a minimum):

802.1Q tag.

Physical Ports.

L. Number of VLANs supported: More than 4,096 VLANs.

M. Redundancy:

The following items shall be fully redundant:

1. Modular Redundant Power supply
2. Processing and Management Engine
3. Switching Fabric
4. Fan

N. Security (as a minimum):

1. Packet Filtering.
2. RADIUS.
3. Access Control Lists.
4. Policy-based Routing.

O. Network Resiliency:

1. Spanning Tree Protocol (STP).
2. Rapid Spanning Tree Protocol (RSTP).
3. Virtual Router Redundancy Protocol (VRRP).
4. Link Aggregation (IEEE 802.3ad).
5. Multi-Link Trunking (MLT).
6. Split Multi-Link Trunking (S-MLT) & Distributed Multi-Link Trunking (D-MLT).

## X202 CORE SWITCH SYSTEM ARCHITECTURE

The core network consists of redundant switching/routing equipment located in the server room of the Administration building.

Based on the traffic analysis, the following connection configuration shall be considered for the core:

A. Each access switch shall have two optical 1GbE uplinks, one to each core switch.

B. Connections will be aggregated, load-balanced and redundant for failover with no downtime.

C. Contractor is to provision for 25% spare capacity in the core network.

The two core switches are to be fully redundant and mirrored such that complete failure of either of the core switches shall result in the other switch taking over the full load of the entire network.

## X203 EDGE/ACCESS SYSTEM REQUIREMENTS

A. Mounting:

1. All equipment shall be rack-mountable.

B. Required Topology:

1. Reliability of solution shall demonstrate equivalent performance such as 800 ms recovery or better.

C. Switch Fabric Capacity:

1. Switching capacity shall be selected to provide non-blocking wire-line speed.

D. Packet per Second Forwarding Rate:

1. Paket forwarding rate shall be selected to provide non-blocking wire-line speed.

E. Supported Protocols and Standards (as a minimum):

1. Ethernet:

a. IEEE 802.3z

b. IEEE 802.3ab

2. Internet Protocol:

a. IPv4

b. System should be IPv6 ready.

F. Management Controls: CLI, SNMP.

G. Minimum Supported Interfaces:

1. Small Form-factor Pluggable (SFP) for Uplink

2. Fixed 100BASE-TX RJ-45 for Downlink

H. Minimum Number of ports required:

1. Access switch ports following the requirements and guidelines as described in the design section and the referenced Sections of this Specification.

2. The Contractor shall account for 25% additional port capacity to accommodate for future growth and expansion.

I. Traffic Management: The following features shall be supported as a minimum:

1. L2, L3 Classifications.

2. IP ToS and 802.1p.

3. Policing mechanism.

4. Shaping.

J. VLAN Support (as a minimum):

1. 802.1Q tag.

2. Physical Ports.

3. MAC addresses.

4. Ethernet, LLC SAP, or LLC/SNAP.

K. Supported Redundancy: The following items shall be fully redundant:

1. Power Supply.

2. Fan.

L. Power over Ethernet (PoE):

1. Switches are to provide an adequate number of Power over Ethernet ports in order to power devices on the network such as IP phones, etc.

## X204 EDGE/ACCESS SWITCH SYSTEM ARCHITECTURE

The edge/access switches shall be managed and shall be addressable via IP addressing.
The general architecture of the switch shall guarantee full rate line forwarding on every line interface module.

The network communication processors shall allow all types of packet filtering such as acceptance, discarding and policing while maintaining the same full rate line forwarding.

The switch shall have high availability including, but not limited to, fully non-blocking switch fabric, fully non-blocking back-plane switching.

## X205 NETWORK MANAGEMENT SYSTEM

The Network Management System offers real-time fault monitoring and management that allows network operations personnel to monitor issues which could impact network latency and performance. Through a variety of data collection and analysis techniques and provides an online graphical display of network alerts and generates intelligent traps, emails and system logs which can be forwarded to other event management systems installed in the network.

The Network Management System features shall include:

Device configuration and management,

Monitoring alerts and activities,

Notification services,

Archiving fault history,

Support for Layer 2 and Layer 3 devices,

Incremental device support.

The Network Management System reporting model should include the following:

Configuration Management - Report on the configuration aspects of network devices such as configuration standards, configuration file management, inventory management, and software management.

Performance Management - Monitor and measure various aspects of performance so that overall performance can be maintained at an acceptable level:

Security Management - The protection of the system components and addressing those aspects of security essential to the operation of the network.

Network Management System Software

Levels:

Software shall provide different access right levels and passwords:

Level 0: no password is required: access to supervision,
Level 1: a password allows to modify a set of parameters,
Level 2: a password allows to enter criteria and parameters.

To reach a level, the operator uses a password to be allowed to enter the system.

Features:

Software shall provide reporting:

Alarm/event history consisting of alarm/event lists,
Operator history consisting of database changes and log-ins by operator.

Software shall allow a backup function.

All associated servers and workstations shall be fitted with the latest virus protecting software.

FIELD AND INSTALLATION WORK

266:1 INSTALLATION

1101 EQUIPMENT INSTALLATION ON SITE is to be limited to the layout, fixation, configuration and operation of the entire telecommunications network, in coordination with all trades and systems that integrate with the system, including but not limited to telephony, security and management applications; as well as inter-wiring of various items of the readymade equipment.

1102 REQUIREMENTS: Contractor is also expected to supply Coordination meetings with the project authorities, owner departments, existing contractors, etc., progress reports and progress reviews, insurance for the transport of the equipment, quality assurance setup and management, document management, configuration management for the duration of the project, off-the-shelf software updates for the duration of the warranty, user documentation and training including textbooks, worksite expenses (setup and removal of temporary offices, worksite vehicles, site offices, computers, printers, desks, etc.) and archival.

1103 SITE SURVEY: Examine all the technical rooms where equipment are to be deployed to identify equipment location, identify links on patch panels, identify and check general power supply and grounding, procure premises environment characteristics ($kW/m^2$, air conditioning characteristics, etc.), make heat dissipation calculation and adjust surface to be used according to rooms environment data and confirm feasibility for each technical room before starting to deploy. Proceed with installation only after unsatisfactory conditions have been corrected.

1104 RACK MOUNTED EQUIPMENT: install rack mounted equipment according to locations, elevations, and plan views developed by the Contractor and approved by Owner Representative. Rack mounted equipment shall be bolted with at least 4 mounting screws for support. Cable guide shall be installed between each 2U rack unit set of equipment to insure patch cable run and adequate air circulation. All rack mountable equipment shall be installed 150 mm from the door and securely mounted in a manner that shall provide access to the connections for testing and allow sufficient cable room for the doors or access panels to open and close without disturbing the cables. Backbone cables shall enter from rear of optical patch panels. Cables shall be maintained with D-Rings. Each cable shall enter patch panel through adequate bushings and inserts where required by Manufacturer’s installation manuals/sheets. All grounding and bonding work shall comply with NEC and ANSI/TIA/EIA standards. All metallic raceway, racks, cable runway, enclosure, and other metallic hardware to be bonded to the dedicated bus bar. Ensure that bonding breaks through paint to bare metallic surface of all painted metallic hardware.

1201 CABLES are to be provided in accordance with Section 265 of the Specification.

1601 TOOLS: use only proper tools for all installation work particularly in mounting devices and making connections.

1701 SUPERINTENDANCE: carry out installations under the direct supervision of a qualified technician, licensed by and trained at the factory.

266:2 TESTS

2101 ON SITE ASSEMBLY VERIFICATION: check the assembly and the connection of the equipment without any power supply.

2102 INSPECTION: verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

2103 PRE-TESTING: align and adjust system and perform pre-testing of all components, wiring, and functions to verify compliance with specified requirements. Correct all deficiencies by replacing malfunctioning or damaged items with new items.

2104 MANUFACTURER'S FIELD SERVICES: engage a factory authorized service representative to inspect field assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming; all results to be reported in writing.

2105 MODES OF SYSTEM OPERATION: testing should be carried out on the functional operation of each field mounted device, and of each control circuit, as well as the supervision function of each initiating, indicating, monitoring, and control circuit.

2106 DEMONSTRATION: the Contractor shall make equipment available for testing and demonstrating various features specified, where the test procedures shall reflect the sequence of tests to be performed.

2107 TYPICAL TESTS: communication tests shall be performed for the LAN interface to ensure that proper communication can be established between data network equipment and the interfacing systems. Point-to-Point tests shall be performed on the data network equipment to the interfacing systems in order to verify the functionality and correct animation of each I/O point/command including alarm messages.

Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by Owner

Representative. The tests are to cover every aspect related to the specification of the system and its operation including, but not limited to, visual inspections, measurements, and operation.

## 266:3 MISCELLANEOUS ITEMS

3310 SPARE PARTS AND TOOL KITS are to be provided as per the manufacturer's recommendations for connection modules, switches, routers and gateways.

3325 TRAINING of personnel is to be carried out during the experimental period. Training of operation and maintenance staff is to be carried out separately. One hour sessions are to be provided for end users. Contractor is to prepare a schedule one month prior to experimental period and submitted to Consultant for approval.

3330 GUARANTEE AND WARRANTY: during the experimental period, the system is to be operating under the Contractor's supervision and responsibility. After the satisfactory completion of this period, the system is to be handed over to the client whereby the two year warranty is to start.

## 266:4 DOCUMENTATION

4401 ACTIVE DEVICES: are to be fully documented to include.

a) Configuration manuals.

b) All implemented configurations.

c) Implementations pertaining to requirements of this document.

d) Manufacturers' Catalogues

e) All relevant Testing Certificates

f) Complete inventory list

g) Three sets of the Maintenance Manuals including a full technical description with block and schematic diagrams to allow staff to maintain the system equipment and components

h) Three sets of the Operation Manuals

i) Data Network schematic diagrams, detailed design, connection diagrams, etc.

j) Racks and cabinet configuration, front and back view

All network devices are to be labeled and mapped accordingly for network management purposes.

# 27 SECURITY SYSTEMS

## 272 ANALOGUE ADDRESSABLE FIRE ALARM SYSTEM

### 272: A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of Sections 201, 202 and 203 of the Specification.

A151 DESCRIPTION OF WORK: complete fire alarm system including the following:

main central fire alarm control unit,

digital data communication network,

satellite fire alarm cabinets,

graphic display station and event logging printer,

automatic detectors,

manual alarm stations,

alarm and sundry devices,

addressable interface devices,

connection of flow switches, valves, fire pumps and access control system, to the fire alarm system as applicable,

complete wiring system, and any related accessories.

A201 REGULATIONS AND STANDARDS: fire alarm system is to be in accordance with the local fire protection Regulations, and in compliance with BS 5839 Part 1 and/or American National Standard NFPA 72, 90A and 101 where not in contradiction with the Regulations.

A301 EQUIPMENT DATA: submit complete technical data for approval including codes and standards, manufacturer’s catalogues and specification, construction and circuit description in detail for each type of component and technology used.

A401 TESTS: equipment is to be tested for quality and operation at the factory, and test certificates, certified by an official testing authority, are to be submitted to the Engineer before dispatch to site.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

detailed system schematic diagram

exact routing and layout of all wireways, conduit and cables, giving type and size with calculations to verify satisfactory wire sizes for all circuits.

exact composition of main and terminal cabinets

terminal numbers and wiring diagrams

typical installation details of cabinets, detectors, stations, alarm devices, etc.

A801 APPROVED MANUFACTURERS: obtain fire alarm system from one of the following:

Honeywell (U.S.A.)

Notifier (U.S.A.)

Simplex (U.S.A.)

Siemens (U.S.A.)

GE Security (U.S.A.)

or other equal and approved.

A851 EQUIPMENT SUPPLIER is to be authorised distributor of manufacturer, and able to maintain a local staff of specialists for engineering assistance, maintenance and repair.

PRODUCTS AND SYSTEMS

## 272: X DESIGN, OPERATION AND COMPONENTS

### 272: X1 SYSTEM DESCRIPTION

X110 DESIGN: fire alarm system is to comprise a number of independent, self-contained, autonomous Satellite Fire Alarm Cabinets (SFAC), connected to a Main Fire Alarm Control Unit (MFAC) in a communication network type system by means of microprocessor-based data communication.

X111 SYSTEM IS TO BE OF MODULAR DESIGN and consist of standardised hardware and software packages only. It is to be possible to expand and modify the system with minimum changes in such a way that already existing system modules are not affected.

X112 COMPATIBILITY: all basic equipment used, except standard peripheral units, shall be designed and manufactured by the same manufacturer to ensure system uniformity of standards, compatibility in operation, parts availability, trained support and maintenance.

X113 DATA TRANSMISSION: data network is to connect SFAC with the main control unit in the control room of the Fire Fighting Station. Standard half or full duplex, digital, serial data transmission techniques are to be used. It must be class A network supervision standards.

X114 DATA TRANSMISSION MONITORING: every path of the data transmission network must be monitored for open and short circuit. Communication faults are to be announced both at the SFAC and the central control unit. A parity bit per byte is to be employed to detect any transmission errors. Manufacturer is to state the types of communication and protocol to be used as well as the standard(s) with which they comply.

X115 TYPE: fire alarm system is to be Class A, 2-wire audibly and visually supervised analogue addressable, zoned, non-coded system. Manual alarm stations and automatic fire detector and sensor circuits are to be grouped in loops.

X120 ADDRESSABLE DEVICES such as automatic fire detectors, manual alarm stations and alarm indicating sounders and strobes are to be individually-addressed in connecting fault-tolerant loops and grouped in software-assignable zones as shown on the Drawings.

X125 NON-ADDRESSABLE DEVICES such as magnetic door holders, water-flow switches, etc. are to be collectively-addressed through addressable monitor and control modules in the connecting loops.

X126 ALARM signal raised at SFAC is to be repeated at the central control unit, located in the Fire Fighting Station Control room, where signals are to be adequately evaluated.

## 272: X2 MAIN FIRE ALARM CONTROL UNIT (MFAC)

X210 DESCRIPTION: central control unit is to consist of the following main components:

a. Central processor.

b. System console for operating and display.

c. Peripherals (printer, colour graphics display, digitizer...)

d. Power supply unit with standby batteries.

X215 CENTRAL PROCESSOR is to monitor and control the entire system and allow control of all satellite control units and other system components connected to the network. The central processor is to be capable of monitoring and processing the data points required for the complete system with at least an additional 30% of spare capacity. The central control unit is to be equipped with dual microprocessor in “hot -standby” mode in such a way that failure of either one, the other one will automatically take over all functions of the central control unit. The failure of any CPU is to be associated with an audible alert signal and distinctive visual signal “PROCESSOR FAILURE” presented at the system main console terminal.

X216 PROGRAM AND DATA CARRIERS are to be used. They must consist of the following:

a. RAM
b. EPROM
c. Disk

X220 HISTORY FILE of all system events, such as alarm, status, fault, operator activities, etc. are to be stored on disk. A record of the last 2000 events is to be maintained on disk to be printed out upon request from the system main terminal

X225 CENTRAL PROCESSOR ARCHITECTURE is to have the following serial input-output interfaces:

a. Front interfaces for either point-to-point or loop communication network.

b. Eight Asynchronous end interfaces for control and supervision of system consoles logging printer and colour graphic display station.

c. At least one additional end interface to drive a digital output device.

d. At least one additional end interface to drive a function keyboard device for dedicated partial system operation.

e. Direct interface with systems such as, elevator grounding, air handling units shutting, etc, through control and monitor modules.

X230 SOFTWARE CONFIGURATION: the manufacturer shall be responsible for the provision of all system software packages which make up the complete operational system. At least the following standard software modules are to be incorporated:

a. Operating program

b. System data base (process image)

c. Network monitoring and control.

d. Display priority control .

e. Command priority control

f. Output message generator.

g. Peripheral drivers.

h. Text/graphic editors.

i. Help facility.

j. Service assistance.

k. Diagnosis

l. Auxiliary programs.

Access to system operating functions is to be protected by a password of 4 to 8 characters. For each operator intervention, the identification number of the initiating password number is to be recorded in the system history file for subsequent reports.

## 272: X3 SYSTEM CONSOLE FOR DISPLAY AND OPERATION

X310 GENERAL: the system console is to automatically display and log alarm and change-of-status messages received from satellite units. The system console is to provide optimal conditions for successful intervention by means of rapid and simple processing and displaying all necessary data in plain text and graphics.

X325 ALARM DISPLAY MODE: the system console is to consist of optical indicators for the basic essential signals and dedicated function buttons for basic system operation, a colour CRT monitor, a mouse for extended system operation and an ASCII keyboard that is used only for special system operation or programming.

X330 COLOUR CRT is to be divided into 3 fields:

a. System summary field displaying system user name, time & date, current basic status function and help instructions for operation.

b. Data field is to display in plain text or graphics all system events and relevant instructions.

c. Dialogue field from where system operation is to be derived. Only the instructions presently valid for the various operating steps are to be indicated here.

The high resolution colour CRT is to have a minimum 10 inches screen size with 24 lines and 80 characters per line plus 8 basic colours.

X335 VISUAL INDICATORS are to be dedicated for alarm, status and fault information. In case of fault or alarm, they are to flash initially and become steady when the alarm is acknowledged.

X340 THE ALARM MESSAGE INFORMATION is to contain the following information:

a. Time and date.

b. Type and origin

c. Description of affected alarm location.

d. Counter-action to be taken.

X345 OPERATING MODE: the extended system operating procedure is to be based on a user adaptive, screen-oriented dialogue in the manner of menus and masks. No knowledge of technical codes shall be necessary for system operation. All messages and instructions needed for system operation are to be indicated in plain text and/or graphics.

X350 ASCII KEYBOARD is to be used for the entry of password for protected operating functions, setting of time and date, assignment of password and operator's access level, editing and modifying data and program parameters, editing and modifying the system's plain customer text and messages and assigning function keys ON or OFF on a specific function/operating board, allowing control of auxiliary relays in an addressed satellite unit.

## 272: X4 POWER SUPPLY UNIT

X410 MAINS POWER SUPPLY: each self-contained unit such as central processor, system terminal and colour graphic screen, is to be able to operate on a mains power of 220 V-AC, -15% to +10%, 50 Hz. Each power supply unit is to have suitable over-voltage protection to prevent any malfunction or damage due to power line surges.

X415 STANDBY POWER SUPPLY: each self-contained unit is to be equipped with a built-in standby battery of nominally 24 VDC, rated to maintain operation for 8 hours after mains power failure. Upon loss of mains power, automatic transfer to standby power supply is to take place, maintaining full operation of the system. When the battery voltage drops below 20 V DC, a fault indication shall be provided on the main terminal. When the system is operating on emergency power, a signal is to be generated on the system console. When the AC power is restored, the power supply unit is to automatically revert to normal operation. The power supply battery unit is to be automatically maintained in charge condition by a built-in short-circuit-proof charger. Nickel Cadmium (NiCd) batteries are to be used for emergency power source. The load is to be automatically switched off when the voltage drops below 19 V to protect the battery.

X420 FAULT INDICATION: each power supply unit and charger circuit, including all fuses, is to be entirely supervised. Any malfunction or blown or missing fuse is to result in a fault indication on the system console.

## 272: X5 SATELLITE FIRE ALARM CABINET (SFAC)

X510 SFAC TYPE: satellite control unit and main annunciation panel of modular design and containing all components of the system including solid-state electronic components, audible and visual unit, relays and interface components, batteries and charger and other components required for operation of system.

X515 SYSTEM OPERATION: the satellite fire alarm control unit is to be field programmed for different alarm organisation schemes, automatically implemented, each according to the fire alarm activating device, and as described below.

Two-mode operation: In case of activation of automatic detector, sprinkler water flow switch, or manual alarm station, the system is to operate as follows:

a. In the first mode of the control unit operation, a response from automatic detectors in designated zones is to be kept as local alarm in the control unit and repeated in the MFAC for the period of a programmable time T1.

b. During this delay time, an internal (staff) alarm (stage 1) only is to be given. If the alarm is not acknowledged before timer T1 runs out, this is to result in a general alarm (stage 2) response.

c. If the alarm is acknowledged while T1 is still running, T1 is to be reset and a programmable timer T2 is to be started. T2 is to delay the general alarm (stage2) further, and so provide time for human investigation of the alarm cause.

d. If no reset action takes place before T2 runs out, a general alarm (stage 2) is to be given, which immediately results in actuating the audible device in the building and the remote transmission of fire alarm to the local fire department or central station service.

e. The initiation of a manual alarm station or response from water flow switch, however, is to (at all times) immediately result in a general alarm (stage 2) response with the above described system action.

f. In the second mode of operation of the control unit, a general alarm is to be given without delay, releasing immediately the actuation of the object's audible circuits and remote transmission of fire alarm to the local fire department or central station service as well.

g. The delay tie T1 (investigation squad check 1) and T2 (investigation squad check2) is to be programmable between 00:00 and 5 minutes respectively.

h. The remaining time of timer T1/T2 is to continuously be displayed at the terminal (count down).

i. The switch-over from first to second mode is to be programmable up to 4 switch-overs.

j. Engineer is to add description for necessary action/initiating signal to be made by the fire alarm system to inteface with either systems, as applicable in the project:

   flow switches, valves, fire pumps, door holders, fans, smoke controls, and access control system.

X516 ALARM VERIFICATION: the Satellite Control Unit is to be programmed for smoke alarm verification such that the first response of an automatic smoke detector is immediately reset, with no alarm initiation. Should a second response in the same zone or detector occur within a fixed time, stage 1 alarm response is to be initiated.

X520 FAULTS AND WARNINGS: satellite fire alarm cabinet is to be designed and programmed to perform extensive automatic self-monitoring. Fire alarm control unit is to give visual and audible warning on main annunciator panel for the following faults:

failure of microprocessor unit or program memory

failure or disconnection of power supply/charger/battery

failure in communication systems or modems

failure of fuse or protective device

removal of detector head

trouble condition in any loop

break or short circuit in wiring of connecting loop or collectively-addressed spurs connected to the monitor/control modules.

Faults are to automatically indicate fault alarm by audible and visual warning. Audible warning is to remain on until silenced by respective cut-off switch whilst red illuminated LED remains on to indicate defective device/loop. When respective device/loop is restored to normal, trouble bell is to sound again until cut-off switch is back to normal, thereby turning off the illuminated LED.

X517 ALARM ACTIVATION: means for activating zone alarm and total evacuation alarm are to be provided, as well as reset buttons for silencing alarm sounders and cut-off switches etc. as necessary to supervise and control the system as described.

X524 LCD DISPLAY: SFAC is to have an LCD display with min. of 2 lines, 20 characters/line to display the alarm information messages.

X525 VISUAL INDICATORS: twin light-emitting diodes (LED), tamper-proof type, with rated life of at least 40 years.

X530 VOLTAGE AND POWER SUPPLY: SFAC is to provide 24 V-DC (±10%) to all alarm initiating and alarm signalling devices and is to be designed to operate from 220 V-AC, 50 Hz & 2-wire, earthed power supply. Over-voltage protection is to be provided to prevent any malfunction or damage which might occur from line power surges.

X535 BATTERY BACK UP ON POWER FAILURE is to exceed 8 hours normal load, followed by full alarm load capability of 30 minutes. Voltage is to be 24 V-DC Battery is to be nickel cadmium, maintenance free type, float charged, with automatic rapid charge at maximum allowable rate for type used. Battery voltmeter, charge/discharge ammeter, low battery alarm bell and pilot light are to be provided, activated when battery voltage drops below 22 V. The connection to the battery is to be automatically switched off when the voltage drops below 19 V to protect battery cells from damage by complete discharge.

X537 UPON POWER FAILURE a visible and audible signal is to be generated to indicate that the control unit is operating under emergency power. The master fault indicator on the control unit is to be also illuminated until mains power has been restored. When the AC power is restored, the control unit is to automatically revert to normal operating without any manual restarting procedures.

X540 CABINET: sheet steel, wall mounted type, finished in bright red baked enamel, with hinged door secured by lock. Smaller lockable door is to be provided in main door for access for routine checking and servicing. Opening of main door is to expose all components for inspection adjustment or replacement, without further dismantling.

X550 RELAYS: plug-in type, fitted with dust-proof covers, operated at 24 V-DC, with auxiliary contacts rated 250 V, 5 A supplied as necessary to operate other systems interconnected to fire alarm system, as required in the Specification or as shown on the Drawings.

X560 LAMP TEST BUTTONS are to be provided to test LEDs or other pilot lights on enunciator panels.

X570 AUXILIARY OUTPUTS: SFAC is to be equipped for transmitting several auxiliary outputs to other systems. It must also be equipped with a serial data communication modem to enable connection to the central fire alarm control unit.

X575 SPARE CAPACITY: SFAC is to have a minimum of 10% spare capacity for future expansion.

272: X6 EVENT LOGGING PRINTER

X610 GENERAL: event logging printer is to automatically record each event/alarm occurring in the system. Event recording is to be recorded with time, date, category (alarm, trouble, etc.) and field-programme description of event location and respective response, if any.

X620 TYPE: printer is to be a 220 VAC, 50 Hz - power operated, 9-pin, impact dot-matrix, bi-directional printer with a minimum of 200 CPS print speed, RS-232C communication with fault conditions reporting to the MFAC for paper out and disconnected or broken cable. Printer parameters are to be set up with a menu-driven program using front-panel switches for selecting options.

X630 FIRE ALARM REPEATER PANEL (FARP): is to be graphical annunciator panel located near the SFAC and semi-flush wall mounted. Graphical displays are to be silk screened lines with colour-coded fire zones on white polycarbonate panel. LEDs are to be mounted to indicate fire alarms, wired to wiring terminal strip. Graphics are to represent each building within the complex with interconnection routes between the buildings. LED indicator is to be provided per each floor in each building, indicating fire condition in the area.

## 272: X7 COLOUR GRAPHIC DISPLAY TERMINAL

X710 GENERAL: graphic display station is to be completely autonomous, fully-operational in case of failure of main processing unit, comprising graphics processor unit, high resolution colour display screen and editing terminal/digitizer tablet.

X720 DISPLAY MODE: the colour graphic terminal shall allow a real time display of all alarms, fault conditions and specific status events in the entire fire alarm system, allowing identification of their origin by:

a. Location of satellite control unit

b. Zone and/or device location.

c. Originating source.

d. Priority of alarm/fault condition.

X730 GRAPHICS presentation shall have a minimum of four hierarchical levels:

a. Area overview

b. Building overview

c. Floor overview

d. Room overview.

X740 GRAPHICS are to be stored in a resident RAM memory and backed-up by a floppy or compact disk memory with the possibility to compose, modify or edit the graphic schematics, text, symbols and zone allocations on-site without jeopardising the fire alarm system operation.

X750 SELECTION AND ACTIVATION of a certain graphic display is to be either automatic (event driven) or by manual request via the terminal.

272: X8 FIRE ALARM CABLING

X830 WIRES AND CABLES: to comply with BS 5839, and certified to have passed BS 6387, EN 60332 Tests on electric and optical fibre cables under fire conditions., BS EN 502265-1, BS EN 502265-2-1, BS EN 502265 . Cables are to be silicone rubber insulated, with overall PVC sheath bonding to coated aluminium foil (FP cables by Pirelli Cables) or other equal and approved. Conductors are to be copper of minimum size 1.5 $mm^2$ and/or as shown on the Drawings.

X835 COMMUNICATION NETWORK between MFAC and SFAC is to be singlemode fiber optic cable provided in accordance with section 265 of the specification.

X840 CONDUITS AND RACEWAYS: to comply with Section 218 of the Specification.

272:X10 MANUAL FIRE ALARM STATION (Pull-Down Type)

X1010 TYPE: the manual call point is to release a true alarm upon pulling-down handle.

X1015 MANUAL FIRE ALARM STATION is to be addressable station and is to have the electronic circuitry for two-way communication with the SFAC. Each time the station is polled, it is to communicate its individual address, type and status. Station is to be automatically addressed through its location in the loop.

X1020 WEATHERPROOF manual fire alarm station is to be identical in operation to the station mentioned in X515 but satisfying the requirements of IP66.

X1030 CONSTRUCTION: tamper-proof, surface or semi-recessed mounting, in suitably designed metal box to permanently withstand corrosion as defined by international standards. Exposed parts are to be bright red. Handle laltches in down position to clearly indicate the station has been operated.

X91040 OPERATION: station is to have operating characteristics compatible with system.

X1050 INSCRIPTION: is to read “PULL-DOWN FOR FIRE ALARM” in raised white characters. Dimensions of inscription are to conform with the Regulations. Other instructions on use of station are to be boldly inscribed.

## 272:X12 OPTICAL SMOKE DETECTOR

X1210 DESIGN: two-wire operation, photo-electric type, utilising light scattering principle, with high quality solid state electronic components, completely shielded, protected against false alarms from EMI and RFI, and obtaining operating power from supervisory current in detection loop.

X1215 DETECTOR is to be analogue addressable and is to have the circuitry for two-way communication with the SFAC/MFAC. Each time the detector is polled, it is to communicate its individual address, type (ionisation-smoke, optical smoke, etc.) and an analogue/digitally encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed by its location in the signalling loop.

X1220 MOUNTING : surface or semi-recessed ceiling mounted type, located as shown on the Drawings, and comprising mounting base and twist-lock detector head. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 100 $m^2$ at mounting height of 6 m. Submit detector's characteristic curves of coverage area against ceiling height and air movement speed.

X1230 SENSITIVITY: detector is to have constant response sensitivity under all conditions due to adaptive alarm threshold. The automatic sensitivity adjustment is to compensate for soiling and climatic influences.

X1250 REGULATION, PROTECTION AND SUPPRESSION: detector is to have automatic regulation to varying supply voltage (18 V - 32 V DC), reverse voltage protection, spike and surge suppression.

X1260 STATUS INDICATION: detector is to have dual status indicating LED's, flashing under normal operation for 360 degree visual supervision. When detector is actuated, LED is to latch-on 'steady' and at full brilliance until reset from control panel.

X1270 PERFORMANCE: detector is to have at least the following performance:

| | |
|---|---|
| nominal operating voltage | : 24 V DC |
| alarm current | : not greater than 5 mA |
| quiescent current | : not greater than 0.2 mA |
| ambient temperature | : 0 to 50 deg. C |

relative humidity : 10% to 90%

ambient air velocity : max. 10 m/A horizontal

protection category IEC529 : IP - 43

smoke entry characteristics : 360 degrees in all directions.

272:X13 RATE-OF-RISE AND FIXED TEMPERATURE HEAT DETECTOR

X1310 DESIGN: two-wire operation, combined rate of rise fixed temperature detectors is to consist of dual thermistors, designed to automatically compensate changes in ambient conditions. Electronic circuits must be solid state devices and virtually hermetically sealed. All circuitry must be protected from EMI and RFI, and must obtain power from supervisory current in detection loop.

X1315 DETECTOR is to be analogue addressable and is to have the circuitry for two-way communication with the SFAC/MFAC. Each time the detector is polled, it is to communicate its individual address, type (ionisation-smoke, optical smoke, etc.) and an analogue/digitally encoded value corresponding to its sensitivity and status with microcomputer processing in the control unit. Detector is to be automatically addressed in its location in the signalling loop.

X1320 MOUNTING: surface or semi-recessed ceiling mounted type, located as shown on the drawings, and comprising mounting base and twist-lock detector head. Removal of detector head is to interrupt supervisory circuit and cause trouble signal at control panel. Normal flat surface coverage is to be over 50 $m^2$. Submit detector's characteristic curves of coverage area against ceiling height.

X1330 SENSITIVITY: detector is to have constant response sensitivity under all conditions due to adaptive alarm threshold. The automatic sensitivity adjustment is to compensate for soiling and climatic influences.

X1350 REGULATION, PROTECTION AND SUPPRESSION: detector is to have automatic regulation to varying supply voltage (18 V - 32 V DC), reverse voltage protection, spike and surge suppression.

X1360 STATUS INDICATION: detector is to have dual status indicating LED's, flashing under normal operation for 360 degree visual supervision. When detector is actuated, LED is to latch-on 'steady' and at full brilliance until reset from control panel.

X1370 PERFORMANCE: defector is to have at least the following performance:

| | | |
|---|---|---|
| nominal operating voltage | : | 24 V DC |
| alarm current | : | not greater than 9 mA |
| quiescent current | : | not greater than 0.2 mA |
| ambient temperature | : | $0^{o}$C to + $70^{o}$C |
| relative humidity | : | 10% + 90% |
| protection category IEC529 | : | IP - 54 |
| Smoke entry characteristics | : | 360 degrees in all directions. |

272:Y OTHER DETECTION SYSTEMS, ALARM AND SUNDRY DEVICES

1272:Y2 ALARM AND SUNDRY DEVICES

Y210 ADDRESSABLE ELECTRONIC SOUNDER: are to run on 24 V DC with voltage variations between 18 V and 32 V and provision for housing the operating mechanism behind a grille. For indoor applications, electronic type will include volume control incorporated inside the unit, mounted on flush box as shown on the Drawings, and giving 87 dB(A) sound level at 3 m in all directions, with a sound frequency in the range 500 Hz to 1000 Hz. The sounder is to operate in both continuous and alternating tones and shall be directly addressable on the signal loop.

Y220 ADDRESSABLE STROBE LIGHT TYPE S1: are Xenon strobe lights with clear or nominal white polycarbonate lens. Strobes shall flash at approximately 1 flash per second and shal be rated at 30 candela. The word “FIRE” is engraved in minimum 25-mm- high letters on the lens and shall be directly addressable on the signal loop.

Y230 ADDRESSABLE ELECTRONIC SOUNDER WITH BUILT-IN STROBE: are factory-integrated audible and visible devices in a single-mounting assembly shall provide the same requirements as individual units. This shall comprise type S1 Xenon strobe light at 30 candela and an electronic sounder. The device runs at 24 V DC with voltage variations between 18 V and 32 V. Sounder will povide audible alarm signal at 87 dB(A) sound level at 3 m in all directions, with a sound frequency in the range 500 Hz to 1000 Hz. The sounder is to operate in both continuous and alternating tones. The device shall be directly addressable on the signal loop.

Y240 MAGNETIC DOOR HOLDERS are to be electrically operated, to magnetically hold doors in an open position, installed on doors as shown on the Drawings. Units are to be durable, die-cast aluminium devices with minimum magnetic projection. Wall portion is to house 24 V-operated, long-life electromagnet activated from SFAC in case of fire. Door portion is to include a stainless steel armature plate, pivotal-mounted on a shock absorbing nylong bearing. Holders are to be surface-mounted, supplied with the necessary mounting accessories and junction box for wiring and terminal connections.

## 272:Y3 ADDRESSABLE INTERFACE DEVICES

Y310 ADDRESSABLE MONITOR MODULE is to be provided to monitor and supervise the wiring of NO or NC-contact, fire alarm non addressable devices (e.g. water flow switches). Wiring to monitor module is to be class-A. Addressing is to be automatic through the location of the monitor module in the signalling loop. An integral LED is to be provided for visual supervision. The LED is to blink each time the SFAC polls the module and latches ON in alarm condition.

Y320 ADDRESSABLE CONTROL MODULE is to be provided to control/activate and supervise the wiring of alarm devices (sounders, emergency voice speaker's zones, fire fighter's telephone zones, magnetic door holders, etc.). Wiring to control module is to be class A. Module is to be provided with SPDT contact, capable of relaying either 24 V dc, 70.7 V audio signal or two-way telephone signal upon command from the SFAC. Addressing is to be automatic through the location of the control module in the signalling loop. An integral LED is to be provided for visual supervision. The LED is to blink each time the MFAC polls the module and latches ON when activated.

Y330 FAULT ISOLATOR MODULE is to be provided within the connecting loops. Module is to isolate the part of the loop upon short circuit in the loop. An integral LED is to be provided for visual supervision, normally blinks and latches ON in alarm.

## FIELD AND INSTALLATION WORK

## 272:1 INSTALLATION

1101 WIRING: cables are to be run in heavy gauge Galvanised steel conduit or in duct banks. Wire sizing schedules and calculations are to be submitted to ensure acceptable voltage drop on all alarm circuits within the system and to indicate various loop wiring layouts in detail. All circuits are to be appropriately labelled and approved before use by Employer's personnel.

1151 MANUAL STATIONS are to be mounted 1400 mm from finished floor level.

1201 CONNECTIONS AND TERMINATIONS of circuits are to be made only at accessible tamper-proof connection boxes and fire alarm cabinets.

1251 DETECTOR HEADS with twist-lock mounting are to be removable from floor level by use of pre-engineered grip on end of long rod, specially designed for the purpose.

## 272:2 TESTING AND ADJUSTING

2101 EQUIPMENT AND LABOUR: provide equipment and labour for site testing of detector heads and sensors including set of shorting plugs with connectors for checking wiring to sensor and detector sockets, and test bench equipment for checking and calibration of all items of system.

2201 TEST FIRES: ensure correct positioning of each automatic detector. Start test fires and measure MPCM (milligrams particulate per cubic meter) using particle detector.

2301 ADJUSTMENT AND TESTS: when exact optimum positions are determined, adjust sensitivity of automatic detectors for optimum safety to false alarms ratio and carry out the following tests:

on all circuits: verification of operation of fault indication for open circuit, short-circuit, earthing, excessive resistance or leakage and removal of heads

general check of functions for main annunciator panel and repeater annunciator panels.

# 273 IP CLOSED CIRCUIT TELEVISION (CCTV) SYSTEM

## 273:A GENERAL

A101 ELECTRICAL WORK GENERALLY is to be in accordance with the requirements of sections 201, 202 and 203 of the Specifications

A151 DESCRIPTION OF WORK: complete closed circuit television (CCTV) system including the following:

The specifications for an IP CCTV System including but not limited to IP Cameras, Video Management Software, Servers & Personal Computers, Data Storage System and other equipment required to operate an IP CCTV Network. This system shall be onward called IP CCTV system.

A161 DEFINITIONS

AC: Access Control.

CCD: Charged Coupled Device.

CCTV: Closed Circuit Tele Vision.

CU: Control Unit.

EMI: Electromagnetic Interference.

EN: European Standard.

FCC: Federal Communications Commission.

FTP: File Transfer Protocol.

GUI: Graphical User Interface.

IEC: International Electro-technical Commission.

IP: Internet Protocol.

ISO: International Standard Organization.

LAN: Local Area Network.

MTTR: Mean Time To Repair.

MTBF: Mean Time Between Failures.

NFPA: National Fire Protection Association.

NMS: Network Management System.

PTZ: Pan, Tilt, Zoom Camera.

SCN: Structured Cabling Network.

SNMP: Simple Network Management Protocol.

SMTP: Simple Mail Transfer Protocol.

SLA: Service Level Agreement.

UL: Underwriters Laboratories.

VLAN: Virtual LAN.

WAN: Wide Area Network.

Camera Functionalities: Defined functional purpose of a camera – as per IEC 62676-4:

Inspect: to enable the operator to obtain information from objects.

Identify: to enable identification of an individual beyond reasonable doubt.

Recognize: to enable the Operator to obtain recognition of an individual.

Observe: enabling characteristic details of an individual, such as distinctive clothing to be seen, whilst allowing a view of activity surrounding an incident.

Detect: to enable the Operator to reliably and easily determine whether or not any target, such as a person, is present.

Monitor: to enable viewing of the number, direction and speed of movement of people across a wide area, providing their presence is known to the Operator.

## A201 REGULATIONS AND STANDARDS:

A. Rules

1. The supply shall be conformed to requirements of referenced industry standards, applicable sections.

2. The supply shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.

3. All equipment shall be specified to function in Marine environment including all the needed protection infrastructure, cabling, etc.

B. Standards

Comply with the latest version of the following standards,

1. System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC)

    a. ISO/IEC 11801: latest edition regarding Information Technology and Generic Cabling for Customer Premise.
    b. ISO 14443 A or B Standard.
    c. EIA/TIA 568, Commercial Building for Telecommunication Wiring Standard.
    d. EIA/TIA 569, Commercial Building for Telecommunication Pathways and Spaces.
    e. EIA/TIA 606 for Telecommunications Infrastructure: This document provides the user of this document with guidelines and choices of classes of administration for maintaining telecommunications infrastructure.
    f. EIA/TIA 607 Commercial Building Grounding (Earthling) and Bonding Requirements for Telecommunications (ANSI/J-STD-607-A-2002).
    g. IEC 60754-1 & 2 Test on Gases Evolved During Combustion of Materials from Cables and Test on Gases Evolved During Combustion of Electric Cables.
    h. IEC 61034-1 & 2 Test and Measurement of Smoke Density of Cables Burning under Defined Conditions.
    i. IEC 60331 Part 11& 12, Tests for Electric Cables under Fire Conditions.
    j. IEC 60332 Tests on Electric Cables under Fire Conditions.
    k. IEC 60364-1 Electrical Installations of Buildings, Fundamental Principles, Assessment of General Characteristics, Definitions.
    l. Comply with the latest issues of the ONVIF Specifications.

2. IEEE: Institute of Electrical and Electronics Engineers

    a. Comply with the latest issues of material and test standards which have been developed and published by the Institute of Electrical and Electronics Engineers (IEEE) 802 Working Group (WG) data communications.

3. ISO: International Standardization Organization:

    a. It promotes the development of international standardization with scientific, technological and economic activities.
    b. The Technical Committee 97, Information Processing, developed a seven-layer communications reference model that allows multiple

protocol and multiple vendor environments to interconnect and operate with one another.

4. Comply, as often as possible, with both ITU-T (International Telecommunications Union) recommendations and US standards. When standards are not compatible in both Europe and US (e.g. telecom interfaces SDH STMx vs. SONET OCx) detailed compatibility and interface availability shall be provided.

5. Building Industry Consulting Service International (BICSI):

   a. Publishes the Telecommunications Distribution Methods Manual (TDMM), which is a comprehensive collection of accepted practices in the design and methodology of communications systems, and the Electronic Safety and Security Design Reference Manual (ESSDRM), which is a comprehensive collection of accepted practices in the design and methodology of electronic security systems. BICSI provides a competency examination for the professional designation as a registered Communications Distribution Designer.
   b. This manual should be used as a reference only.

6. Network Equipment Building System (NEBS):

   a. Level 1, Level 2, and Level 3 are applicable to these section.

C. Precautions:

1. The above list is a partial list issued from standard organization. Additional consideration may be required to provide protection of communications equipments, data processing equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

A301 EQUIPMENT DATA: submit data for approval including catalogues and literature, sufficiently detailed for engineering purposes, and with full description of component and operating parameters. Submittals are to include also:

Monitoring technique of video and control signals

system expandability

operating parameters and limitations, ambient conditions, heat dissipation, power requirements, etc.

recommended FO/CAT6 specifications and characteristics.

A401 TESTS: equipment is to be tested for quality and operation at the factory, and test certificates and reports are to be submitted to the Engineer before dispatch to site.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit for approval including, but not limited to, the following:

Detailed system schematic diagram

Exact camera locations, layouts and mounting details.

Configuration and construction details for operating console and layouts with equipment located in as – installed positions.

Complete and detailed cable routing and layouts with calculation losses and signal levels.

Wiring diagrams are to bear manufacturer's signature indicating that they have reviewed the drawings and that they are correct in respect to sizes, wiring and configuration and will operate in accordance with function, scope and intent of the specifications.

A801 APPROVED MANUFACTURERS: obtain CCTV system from one of the following:

| | |
|---|---|
| Axis | (Sweden) |
| Indigo Vision | (U.S.A.) |
| Honeywell | (U.S.A.) |
| Sony | (Japan) |

or other equal and approved.

A901 MAINTENANCE

A. Support

1. The Contractor must offer a comprehensive explanation of its Service Level Agreement (SLA) policy. The SLA should cover at least the following performance terms:

    a. 99.999% availability. GTI and GTR should be guaranteed accordingly.
    b. Emergency level 24/24, 7/7 phone support shall be available. Distant intervention on system must be offered.
    c. High-level problem investigation support must be offered 5/7 during working hours.
    d. Maintenance stocks must be properly sized by the Contractor in order to match operational quantities replacement needs given Manufacturers MTBFs for each equipment and components within the network.

2. Maintenance service must include:

    a. Contract lifetime software patching for revealed problems during operations.
    b. Contract lifetime hardware replacements on established malfunctions or weaknesses generating repetitive loss of service quality
    c. Repairs in reasonable time for factory returned equipment.

B. Maintenance Service

1. During the Warranty Period, Manufacturer or factory-authorized agency shall maintain a service center capable of providing spare parts and emergency maintenance and repairs for the overall system at Project site 7 days a week and 24 hours a day. Competent personnel shall be dispatched to rectify stoppages at any time during the day or night when being called on by the Employer.

2. The Contractor shall submit a Service-Call Report to be sent to the Employer immediately following every call out, indicating the time of call out visit, cause, remedial action taken and the time that the service was restored.

3. A Maintenance Manpower Plan shall demonstrate the Contractor's committed resource level available for all types of activities to be carried out within the Warranty Period. Such plan shall be submitted for Approval six months before commencement of the Warranty Period.

4. The Contractor's response time, during the Warranty Period, shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.

5. During the Warranty Period, the MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on site, but shall exclude the response time.

6. During the Warranty Period, the monthly average of the Repair Time shall be lower or equal to six minutes for each device. This performance will be checked.

7. The Contractor shall liaise with the Employer's Representative and carry out safety and performance inspections for the installation on site. Any necessary adjustments to the installation shall be made within 14 days of completion of such checks. A Safety and Quality Report shall be submitted, no later than 14 Days after such safety and performance checks, for the Employer's Representative's approval.

8. The Contractor shall provide at least four inspection visits at six-month interval during the Warranty Period.

9. The Contractor shall be responsible to clear away from the Site all surplus materials, rubbish, temporary works of every kind and leave the whole of the

Site and installation clean and in a workmanlike condition to the satisfaction of the Employer's Representative, upon completion of each item of the repair, and maintenance works.

C. Maintenance Performance Data

1. Updates

a. The system will have to be conceived to facilitate the updates that will take place throughout its life. The replacement in exploitation of a version of software by the following one must be an easy operation, without risk, rapid and reversible.
b. This update shall be transparent for the user and shall be done without interruption of the service.

2. Corrections

a. In the event of error, the system shall have, as soon as possible, to store in a file a certain number of information allowing the correction of this error, e.g. entries in the transactions, faulty operations of the statistics, etc.

PRODUCTS AND SYSTEMS

273: X CLOSED CIRCUITS TELEVISION (CCTV) EQUIPMENT

273: X1 DESIGN AND OPERATION

X110 GENERAL REQUIREMENTS: CCTV system is to provide complete colour camera surveillance for areas shown on drawings, with sequential switching and manual switching of camera outputs, giving facilities to record selected camera outputs.

X130 DESIGN: system design is to include the system components as shown on drawings and not be limited to the following:

X131 WORKSTATIONS, SERVERS REQUIREMENTS:

A. The PCs or system workstations are used for surveillance and alarm viewing as well as for data storage. The PCs shall be installed in a console in the control tower of the Administration Building.

B. System application and data storage servers shall be installed in the Server Room located in the Cargo and Container Building, ground floor.

C. Provide three workstations for CCTV monitoring , however should the client require to add more workstation, they shall be added with same cost of the first 3.

D. Workstation shall have the following minimum features and requirements:

1. Screen size: 2 x 21” SXGA, LCD type

2. The Processor shall be of the latest available types to support the full functionality of the CCTV system.

3. VGA Card with minimum range of 8GB (with dual monitor).

4. HDD : minimum of 1TB SSD type.

5. Network Card: 100/1000 Mbps.

6. Keyboard: full size QWERTY.

7. Operating systems: Windows, or Linux.

8. Operating temperature: +10° C to +55° C.

9. Operating Voltage: 220V AC ±10%, 50 Hz.

E. The system shall allow flexible storage architecture (centralized, local, and remote storage) for enabling best storage utilization.

X131.A STORAGE CONSIDERATIONS:

A. The system shall support a wide range of automated video storage options ranging from as little as a few hours of online storage capacity to keep long-term storage using hard drives, digital tape or other cost-effective long-term storage media. The system shall be capable of supporting unlimited video storage capacity by enabling system Operators to periodically remove and replace hard drives, tape cartridge, or other removable storage media.

B. The system shall allow flexible storage architecture (centralized, local, and remote storage) for enabling best storage utilization.

C. The system shall provide sufficient storage for all camera recordings for a period of 90 days, in H.265, H.264 or MPEG-4 format or better quality compression techniques. The recording frame rate and resolution must be programmable at user level. It shall be possible to customize the quality of the video output based on the viewing needs and storing capacity.

D. Recording period shall be coordinated with the Employer, Police and related Operators.

A. The storage system shall be equipped with a database mirroring and distributed video storage features, which shall allow the system to sequentially distribute

recorded video among the installed hard disks. And therefore, in case of a hard disk failure, the user shall be able to receive a relatively reduced frame rate, but shall not lose the complete video sequences.

B. Recorded and stored images shall be accessible from any workstation PCs connected directly to the LAN or via remote connections.

C. The Contractor shall submit design calculations to justify the selection of the hard disk or other storage media and the capacity and type of the storage library.

D. The following criteria shall be adopted to determine the minimum storage capacity for each Project **building** and site:

1. The Motion Ratio which is the average number of hours that the camera's recording is subjected to motion detection, and is defined as follows:
    a. Cameras are assumed to have a Motion Ratio of 12 hours per day.

E. The Storage shall be designed for high speed, high capacity digital video storage and high performance playback applications.

F. The Contractor shall accommodate any changes in Specifications from the Authorities Having Jurisdiction before final approval.

G. It shall be the responsibility of the Contractor to provide sufficient storage.

H. The Contractor shall provide all supporting calculations including network bandwidth calculations and all other parameters used in the assessment of Storage requirements - for review and approval by the Employer.

I. The Contractor shall provide updated SAN calculations proposed upon the final selected cameras and video management solution.

J. The Contractor shall confirm that the calculated storage requirements are correct during the testing phase of the Project. This shall be in the form of a submittal that shall also include documentation stating successful completion of the System Availability testing.

K. It shall be the Contractor's responsibility to confirm the bandwidth necessary to support the VSS traffic on the Project LAN.

L. The storage must support redundancy or recording scheme with RAID 6 features.

1. Continuous recording shall be implemented at the capture frame rate of the camera. However, the default frame rate could be reduced if an alarm trigger mechanism is deployed that would cause the frame rate to increase on activation.
2. Any system that relies on frame rate increasing after alarm trigger should buffer the video so that several seconds before the alarm trigger is captured at the higher frame rate.
3. The minimum frame rates of cameras shall be as follows:
    a. Identification: 12.5 fps

b. Recognition: 12.5 fps
c. Observation: 6 fps
d. Detection: 2 fps

4. The alarm ratio per Camera, which is the average percentage of time that the Camera will be triggered by an Event/Alarm and is dependent on the camera location. The alarm ratio shall be coordinated with the Operator(s) and shall be greater than 20%.
5. The Camera Mode, which shall be coordinated with the Operator(s) with respect to each camera location and ambient light conditions and is generally classified per day on the following basis:

   a. 12 hours Day Mode
   b. 12 hours Night Mode

M. Scheduled Recording Administration:

1. The system shall be able to establish a recording schedule based on hours of the day and days of the week.
2. The system shall be able to specify the times during which each camera will be recorded along with the recording settings to be used during each period including the frame rate, resolution, and quality settings.

N. The storage system shall be designed to work with the Network Management System in order to send recorded pictures to all monitors or remote workstations on request.

O. Surveillance Requirements

1. The below listed figures are indicative and are provided to assist the Contractor in choosing the required resolution of the CCTV cameras at specific locations. Contractor to develop and finalize the below requirements and shall submit a matrix covering all the Project buildings and site plan monitored areas for the Engineer’s approval.
2. Cameras installed in the following locations shall support Identification:

   a. At all buildings entrances.

3. Cameras installed in the following locations shall support Recognition:

   a. At all the corridors and waiting areas.

4. Cameras installed in the following locations shall support Observation:

   a. For common monitoring .

5. Cameras installed in the following locations shall support Detection:

   a. For fence, camera should also interface with other PTZ cameras to signal any intrusion..

6. Cameras installed in the following locations shall support License Plate Recognition:

a. At all entrance barriers .
b. At all entrance and exists of container yards
c. At entrances to parking spaces

7. Cameras installed in the following locations shall support Container tag reader OCR:

a. At all entrance barriers
b. At costumes check point.

## X132 NETWORK MANAGEMENT SYSTEM AND SYSTEM SOFTWARE REQUIREMENTS

A. The network management system shall be full-featured video matrix switching system allowing users to view and control each camera in the system from different nodes within the network.

B. The system shall include built-in video loss detection and system diagnostic features. Video loss detection alerts operators of a camera failure. Diagnostic monitoring assists in set-up, programming, and troubleshooting.

C. Matrix software shall allow for the activation of specific applications such as incremental switching mode (cyclic) and connection of alarms, event-actuated sub-routines, and for preventing or permitting various outputs.

D. The system shall be equipped with suitable and efficient backup mechanisms including backup management for archiving and restoring information.

E. The system shall provide a Graphical User Interface (GUI) that shall satisfy the following requirements:

1. A user-friendly operator interface for monitoring and controlling the system through a Windows environment through the use of a computer mouse.

2. Multiple, linked graphical maps including site and building floor plans. Icons placed on graphical backgrounds shall be used to select, control, and monitor each camera in the IP CCTV System.

3. Simple and logical navigation between graphical maps.

4. A master graphic to direct operators to more detailed graphics. The GUI shall allow the operator to select the master graphic from any other graphic. Each map shall include camera and monitor icons located within the graphic area, and shall include icons to allow the operator to navigate between other areas near the current map.

5. Import of graphics generated by other drawing programs. Include a conversion program with the system to convert DXF files from CAD programs into the format used by the system.

6. Graphical map with high quality showing floor details including all partitions, doors and other major built-in structures.

7. Overview of all incoming alarms, including filtering possibilities and control of multiple users handling the same alarm.

F. The system shall provide multi-level password protection and logging facilities that:

1. Grant and/or deny rights to individual users or groups of users.

2. Restrict the ability to modify the system configuration.

3. Restrict access to video from specified cameras.

4. Restrict access to alarm events.

5. Restrict access to troubleshooting tools such as remote control functions.

G. The system shall allow playback and recording of cameras simultaneously.

H. The system shall allow simultaneous audio recording and playback.

I. The system shall allow playback with high speed date/time searching, skip searching, index searching, alarm list searching, and multi-screen option.

J. The system shall allow playback digital zooming (as an option); it shall allow the operator to zoom into a selected area of the image during playback and video authentication.

K. The software shall have the flexibility to be programmable for any recording or playback sequence.

L. The system shall provide remote P/T/Z camera control through web server.

M. The system shall be capable to notify users about its status and alarms by sending e-mails to a predefined address using SMTP.

N. The system shall allow for recording of up to 30 frames per seconds.

O. The software shall provide the ability to limit storage of recorded video by automatically deleting recorded contents when the information reaches a pre-defined duration or date. The setting of these parameters shall be available on a per camera base, allowing for different settings for each camera.

P. To secure recorded video from being lost, the system shall allow an authorized user to manually “lock” recorded material from being erased or overwritten.

Q. Recording shall be capable of using standard motion JPEG format without any modification of the pictures, and MPEG-4/AVC.

R. The system shall allow a recording quality: JPEG up to 2Mega pixel, 1280 x 1024 pixels, other PAL resolutions include 320 x 240, 352 x 288, 640 x 480 or 704 x 506 depending on the camera/server.

S. The system shall allow the export of video recordings in JPEG or MP4 format and any other standard base format to the approval of the Employer's Representatives.

T. The system shall provide the ability to export single video pictures to JPG files as well as video sequences to MP4 files.

U. The system shall allow search on time, date or activity/alarm with instant playback in real time with audio.

V. The system shall provide the ability to send operational and technical information using a standard SMTP mail server. To ensure availability, a minimum of two different mail servers must be definable.

W. To avoid improper use and configuring, the system shall provide the ability to define users and passwords for a minimum of three different types of users.

X. To ensure availability of video related to an alarm, the system shall provide a freely selectable pre and post-alarm recording. The duration of the pre-alarm time shall not be limited.

Y. The system shall provide the ability to link events to selected time only, i.e. during out-of-office hours.

Z. The system shall be able to select cameras to be recorded including date & time, title, update rate (real time and/or time lapse).

AA. Protocols supported, as a minimum: TCP, UDP, IP, HTTPS, FTP, SMTP, NTP, ARP, DHCP, DNS.

## 273:X2 CAMERAS AND ANCILLARIES

### X210 IP CAMERAS REQUIREMENTS

A. A network camera is a device including the following:

1. Lens.
2. Optical filter.
3. Image sensor.
4. Image digitizer.
5. Image compressor.
6. Zoom.

7. Built-in software for web server with network connectivity.

B. Camera types:

1. Type 1: Indoor, fixed, anti vandal and mini dome color camera.

2. Type 2: Outdoor, weatherproofed, anti vandal and thermal camera.

3. Type 3: LPR Cameras

4. Type 4: OCR Cameras

C. The IP camera shall provide real motion frames per second, i.e. up to 25 frames/s (PAL) and 30 frames/s (NTSC).

D. The IP camera shall be equipped with audio support functionalities.

E. The IP camera shall be equipped with motion detection functionality and alarms input/output with e-mail support.

F. Zoom:

1. Manual.

2. Fixed.

3. Manual with support for external control.

4. Optical and digital zoom.

G. Image Size:

1. 1920x1080 (1080p)

2. 1280 x 720 (720p)

3. 736 x 480.

4. 640 x 480.

5. 320 x 240.

6. 160 x120.

H. Compression:

1. JPEG

2. MPEG-4/AVC

I. The Contractor shall field-verify lens requirements for the defined design and angle of view for high quality, glare free, clear pictures at the video monitors.

J. Image Device: High resolution color CCD camera with an enhanced CCD sensor, solid state circuitry, and state of the art electronics incorporating the latest in digital technology. The color CCD sensor shall be:

1. 1/6 inch 68K.

2. 1/4 inch/ 38K.

K. Light sensitivity:

1. 1 lux with f/1.4 lens.

L. Network Interface:

1. 10/100BASE-TX.

2. Fiber optic single mode LC connector as per the design drawings and the site requirements.

M. Software: The IP camera shall be equipped with built-in software for:

1. Web server.

2. FTP server.

3. FTP client.

4. E-mail client.

N. Supported Protocols, as a minimum: TCP, UDP, IP, FTP, SMTP, DHCP, DNS, SNMP, ICMP, and HTTPS.

O. Image Buffer: 8MB.

P. Power: Built-in Power over Ethernet (IEEE 802.3af at least) support. The cameras shall also be able to connect to direct power source. The Contractor shall check and upgrade the power installation design to assure that the required feeding type of camera power (12V, 24V, 220V, AC, DC, etc.) is provided.

Q. The camera shall support both fixed IP addresses as well as addresses provided by a DHCP server.

R. Camera Housings and Mounts: the housing is to provide long term protection of cameras, lenses, control electronics, UTP/Fiber converters and accessories. It shall be designed to withstand direct solar heat and ambient conditions (dust-tight, waterproof, saline environment, etc.).

1. Wiring to all cameras shall pass from the back box through the mount and into the housing. Exposed wiring of any kind shall not be acceptable.

2. Provide sun shields for camera housings in outdoor locations exposed directly to sunlight.

3. Provide weather and dust proof camera housings with thermostatically controlled heaters and blowers in outdoor locations.

4. Provide lightning protection for all exterior cameras.

S. LICENSE PLATE RECOGNITION (LPR) SYSTEM/CONTAINER NUMBER REGOGNITION

1. License Plate Recognition (LPR) system is an image-processing technology used to identify vehicles by their license plates, also referred to as Car Plate Number Identification system.

2. The LPR/OCR system shall consist of the following units:
   a. Camera(s) - that take the images of the car/truck.
   b. Camera for OCR shall take images of the container plater number
   c. Illumination - a controlled light that can bright up the plate, and allow day and night operation. In most cases the illumination is Infra-Red (IR) which is invisible to the driver.
   d. Frame Grabber - an interface board between the camera and the Workstation that allow the software to read the image information.
   e. Computer - a Workstation running Windows or Linux. It runs the LPR application which controls the system, reads the images, analyzes and identifies the plate, and interfaces with other applications and systems.
   f. Software: the application and the recognition package.
   g. Hardware: various input/output boards used to interface the external world (such as control boards and networking boards).
   h. Database - the events are recorded on a local database or transmitted over the network. The data includes the recognition results and (optionally) the vehicle or driver face image file.

3. General Features
   a. The LPR/OCR System shall seamlessly integrate with the access control system software.
   b. The LPR/OCR shall integrate with port accounting and container management systems to allow follow up of container/track movement around the port from the entry of each (truck or container) till their departure.
   c. The system shall be able to check automatically the car plate number/OCR as well as the type, the shape, and the color of the vehicle (to ensure that the plate number has not been changed to another car) or container.
   d. The image information shall be read, analyzed and recognized automatically by the LPR/OCR System.
   e. A typical image might be composed of 256 grey levels ranging from black (grey level 0) to white (grey level 255). For a typical format there are 768 X 288 pixels (Picture Elements), or about 0.2 million elements. This vast amount of information shall be processed by the recognition software in order to automatically locate and read the plate.

f. The computer processing shall work on the global information (the entire image) for detecting the plate then zoom into the data in order to handle the small details and finally extract the registration data.
g. The end result of the recognition process is a string of characters representing the plate number. This transformation of the image data into a result string shall be seen as a very large compression of the original raw data.
h. Since the vehicle plates are based on different country standards, they are different in form, shape and material. Therefore, the system shall be made specific for Project area shall be adapted to read and recognize local car plate number formats.
i. A camera footage of 10seconds shall be stored for later forensic auditing, period of storage shall be validated with the client.

4. Camera Applications
   a. Coordinate camera specifications with the Drawings.
   b. Use 2 Megapixel Resolution Fixed Cameras for License Plate Recognition.
   c. Use 2 Megapixel Resolution Fixed Cameras for OCR

## X211 SECURITY LIGHTING

A. It is the responsibility of the Video Surveillance Contractor to liaise with the concerned Contractors to ensure adequate lighting conditions are achieved.

B. If the lighting levels were inadequate, Security Lighting shall be provided by Infrared or warm white illuminators depending on the location and operational requirements. Illuminators shall be of the LED type and shall use the latest LED technology to provide a long operational life and low energy consumption.

1. The infrared unit shall be a solid state LED device

2. The LED illuminator shall be available in different wavelengths including 850 nm and 950 nm.

3. The illuminator shall include a dedicated power supply unit (PSU) with a power adjust facility, an integrated photocell for automatic day/night switching and a volt free telemetry input.

4. The illuminator and the PSU shall be IP66 rated as a minimum.

5. The illuminator shall be capable of being switched On/Off via a PIR occupancy detector.

6. The LED Illuminator shall be vandal-resistant and manufactured with high impact polycarbonate lensing.

## X212 CCTV COLUMNS

A. Construction: Columns are to be circular section, tapered, formed sheet steel, powder paint coating finish, (color to be approved by the Engineer), electrically welded, and of height specified. Columns up to 12 m height are to be one-piece section. Columns above 12 m and up to 20 m height may be supplied in two-piece sections, of the slip joint type with sufficient overlap to ensure correct vertical alignment of column after assembly. Columns are to have minimum wall thickness of 3 mm at base. Sheet steel is to have minimum rupturing resistance of 37 kg/mm2 and minimum yield strength of 24 kg/mm2. The height of the column shall be based on the required CCTV cameras field of view.

B. Top of column is to be designed to receive single or double arm brackets or other arrangement required, supporting number of CCTV cameras shown on the Drawings. Bracket arrangement is to be designed to ensure that failure, due to wind induced oscillations, does not occur and that rotation from desired alignment is not possible.

C. Column Design: Column cross-section, thickness of steel, joints, welds, bolts etc. are to be designed to withstand gust wind velocity of 160 km/hr blowing in the most unfavorable direction at a height 10 m above ground level, with column fully equipped. Fatigue of steel is in no case to exceed half elasticity limit, taking into account dynamic stresses due to vibrations. Steel flange plate, of adequate thickness, is to be solidly welded onto lower edge of column as shown on the Drawings, and is to have specified number of holes for holding down bolts together with central cable access hole not less than 150 mm diameter.

D. Access door of weatherproof construction, with non-degradable heat resistant rubber gasket, is to be positioned at column base and is to be suitably sized to insert and service the supply cable terminations and protective device. Door is to be flush fitting with retaining mechanism and positive locking arrangement with removable hexagonal key. Column is to be reinforced at door opening. Opposite each door, a non-hygroscopic baseboard of suitable size to accept appropriate equipment is to be fixed to inside of column by purpose-made brackets. Steel earthing stud with washers and nuts is to be welded inside the column near the access door. Also provide the needed earthing system at each pole base. The earthing shall also connect to the cameras chassis through an internal cable inside the pole.

E. Finish: Columns shall be of stainless steel type to defend against the saline environment, otherwise and if the client would approve, poles can be substituted with steel type with an external powder paint coating (color to be approved by the Engineer). Welds are to be smooth with spatter removed; inside and outside surfaces of column are to be cleaned by pickling or blasting and are to be free of grease. Steel components of columns to be hot-dip galvanized after fabrication. Minimum thickness of zinc coating is to be 500 g/m2 on both inside and outside surfaces of column. Galvanizing is to be to BS EN ISO 1461. Any damage to galvanizing is to be rectified during erection by wire brushing affected area and treating with approved rust converter to the satisfaction of the Engineer. Flange plate and inside and outside of column base are to be coated with heavy bitumen paint prior to erection.

F. IP rated “cut-out” weatherproof enclosure box to be provided at base of pole containing media converters and cable terminations. Fixing/holding screws shall be captive type.

G. Terminal blocks shall be high temperature, non-inflammable, non-toxic material with high quality fixing screws. Individual terminals for each termination.

H. Wiring is to be PVC insulated 3 core or 4 core, heat resistant type to 105 deg. C (221 deg. F) conductor temperature.

I. CCTV column final selection shall be subject to the approval of Engineer and/or Employer

J. Cameras height on the pole depends on the usage of the cameras:
   1. For general monitoring (fixed and PTZ cameras), provide cameras at 5-6 m height and depending on manufacturer selection.
   2. For LPR/OCR: provide cameras at 3-4 meter to monitor the LPR/OCR, and depending on manufacturer selection

## 273:X7 ETHERNET MEDIA CONVERTER

X710 ETHERNET MEDIA CONVERTER: UTP to Fiber converter for pole mounted, outdoor CCTV cameras.

X720 CONVERTER REQUIREMENTS:

- Converts 10/100BASE-TXX to 100BASE-X, as a minimum.
- MDI/MDI-X Auto-Crossover supported
- Auto-Negotiation or manual mode setting of speed and duplex mode
- Power, network speed, network Tx & Rx status and optical Tx & Rx status LED indicators
- Single/Dual fiber(s) operation with LC fiber connector
- Distance up to 5 km (with singlemode fiber)
- Comply with IEEE 802.3 10/100BASE-TX and 100BASE-X standard
- Plug-and-Play
- 12VDC or 220VAC power

## 273:X8 CABLING AND DISTRIBUTION SYSTEM

X810 VIDEO SIGNAL CABLE: CAT 6 cables, refer to section 265.

X830 POWER CABLES: 3 single cores, with copper conductors minimum 2.5 $mm^2$ cross-section, PVC insulated (70 deg. C insulation grade), and as described in Section 217 of the Specification.

## 273:X9 LAN INFRASTRUCTURE SYSTEM REQUIREMENTS

X910 The requirements are:

A. LAN equipment are not part of this Specification; however, in order for the IP CCTV system to function properly the LAN infrastructure shall have as a minimum the features listed below.

B. Protocols: TCP/IP.

C. Traffic Management and Quality of Service Mechanisms.

D. VLAN/VLAN tagging (802.1q) support.

E. Hardware Redundancy.

F. Security Features.

G. Network Resiliency Features.

H. Power: Power over Ethernet support (IEEE 802.3af).

## 273:X10 ALARMS AND EVENTS

X1010 The alarms and events are:

A. Overview: For the purpose of these Specifications, an “alarm” is any event that can be received or detected by an external equipment (access control for example) or internal (failure for example) and responded to in real time. Many types of events are not “alarms” in the traditional sense of an immediate problem such as a fire or intruder. An event can be any type of activity that may be the subject of future investigation and video review. The two basic requirements for an event are time and location:

   1. Time: A signal or data that can be detected or received in real time.

   2. Location: A physical location associated with the signal or data that can be related to cameras and camera presets.

B. All the pictures shall be recorded and stored, continuously or on event. The operation cameras output shall be recorded all the time. The security cameras output shall be recorded on event with pre and post alarm.

C. Alarm Recording: The system shall be equipped with Alarm Recording function that:

1. Enables the system administrator to define alarm responses including instructions to trigger recording of specified cameras at specified frame rates and quality settings.

2. Enables system administrator to determine the pre-alarm duration.

3. Record cost-effective low frame rate video during non-alarm periods, and then start recording at high frame rate (real-time) in response to alarm events.

4. Enables system administrator to determine whether video will be retained on long-term storage media for each continuous or scheduled recording instruction and automatically retain video on long-term storage media when video is recorded as part of a defined response to an alarm event.

D. Tasks Related to Alarms: The system shall be able to perform the following tasks:

1. Execute video image analysis algorithms (video sensor), including activity detection and video loss detection and generate alarm messages.

2. Receive signals from alarm inputs and generate alarm messages.

3. Send alarm messages to the server or program that manages alarm responses.

4. Process alarm response instructions, change recording modes and control alarm relay outputs.

5. Forward alarms from a remote node to a central alarm monitoring site, including modem or LAN/WAN communication.

6. Motion detection feature shall be provided for fixed cameras looking at sensitive areas, in order to initiate alarm when unauthorized movement is detected. The Contractor shall coordinate and check precise location.

E. Event recording mode shall be used in relation with the Security System for access controlled doors.

F. The system shall perform the following tasks in response to requests from one or more workstations:

1. Supply one or more live video streams.

2. Enable one or more users to playback previously recorded video, including “instant replay” of video recorded within the last few seconds.

273:X11 INTERFACES

X1010 The IP CCTV System shall be integrated and interfaced to the following systems:

Structured Cabling Network: The system shall be interfaced with the Structured Cabling Network to allow the communication between the work stations, recording and storage servers, Network Management System, and all other interfaced systems through the network backbone.

Access Control System: The system shall be interfaced with the Access Control System in order to allow for a fully integrated security solution for the project.

## FIELD AND INSTALLATION WORK

### 273:1 INSTALLATION

1101 EQUIPMENT: install in accordance with manufacturer's instructions and to the approval of the Engineer. Mount equipment in alignment with other building fixtures and fix firmly in place with all supports and fastenings secured.

1201 INTERFERENCE PROTECTION: equipment is to be installed to prevent electromagnetic, electrostatic or other outside interference impairing system performance.

1301 ACCESSIBILITY: equipment is to be installed to be readily accessible for operation, maintenance and repair. Minor deviations from the Drawings may be made, but no changes are to be made without prior approval.

1401 MAKE GOOD surfaces of equipment damaged during installation, using touch-up paint provided by equipment manufacturer, to the satisfaction of the Engineer.

1501 ROUTING of video signal cables, power and control cables, in general, is to be in separate raceways.

### 273:2 TESTING AND TRAINING

2101 SUPERINTENDENCE: equipment manufacturer is to provide an engineer and technician qualified in the operation of the system and equipment performance and the requirements of the Specification, to assist the Engineer to test and verify the system performance.

2110 FACTORY TESTS

A. Factory Acceptance Tests

1. The Factory Acceptance Tests shall be carried out in a hardware and software environment, which simulates the final configuration of the system.

2. The Contractor shall carry out any Factory Acceptances Tests, in Manufacturer's factory itself, before any site delivery, in order to show to the Employer site Engineer that the system of both hardware and software and the system after integration of various sub-systems is able to satisfy site technical requirements of the equipment specifications.

3. Some of the functional or performance tests, which cannot be conducted in a simulated environment, due to their nature and complications, may subject to the Employer's Representative's approval be combined with the On Site Tests.

4. All travels and trips costs shall be provided by the Contractor for five (5) representatives to be nominated by the Employer.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.

2. The tests are to cover every aspect related to the specification of the system and its operation; including, but not limited to, visual inspections, measurements, and operation.

3. All Factory Acceptance Tests need to be carried out in the presence of the Employer's Representative unless otherwise agreed by the Employer's Representative. The Employer's Representative will sign off the testing document on satisfactory completion of the tests.

4. All Factory Acceptance Test Specifications, at every level, shall be subject to configuration management and change control by the Contractor.

5. The results of the Factory Acceptance Tests, together with any re-testing as a result of failure, shall be recorded and signed by the authorized personnel of the Contractor and the Employer's Representative.

C. Equipment Tests

1. Equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Employer's Representative before dispatch of equipment to site.

## 2120 ON SITE TESTS AND INSPECTION

A. On Site Assembly Verification

1. The purpose of this phase is to check the assembly and the connection of the equipment without any power supply.

2. Any verification can give raise to a punch list item either because of an anomaly or a none-conformity with the tender documents.

3. The punch lists are collated for each module and the phase report is only released when all the stipulations on the punch lists are cleared.

B. Test Specifications

1. Following the methodology presented in the Test Plan, all tests are to be carried on according to Test Specifications, which are submitted by the Contractor and approved by the Employer's Representative.

2. The tests are to cover every aspect related to the specification of the system and its operation including, but not limited to, visual inspections, measurements, and operation.

C. On Site Cable Tests

1. Cables are to be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling in and laying.

D. Inspection

1. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

E. Pre-Testing

1. Align and adjust system and perform pre-testing of all components, wiring, and functions to verify compliance with specified requirements.

2. Correct all deficiencies by replacing malfunctioning or damaged items with new items.

F. Manufacturer's Field Services

1. Engage a factory authorized service representative to inspect field assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming.

2. Report results in writing.

G. Procedure

1. Notify the Employer's Representative not less than 30 days in advance, of proposed schedule, procedures and tests to be used in operational testing.

2. Conduct operational tests only with the Employer's Representative present.

H. Report

1. Prepare a written report of observations, inspections, tests, and results, including:

   a. A complete listing of every device and circuit,
   b. Date of each test and retest, and by whom,
   c. Results of each test and, if failure occurred, corrective action taken prior to retest.

I. Certification

1. The Contract shall certify that all devices, circuits, and total system are finally tested successfully.

J. Operational Tests

1. Schedule tests after pre-testing has been successfully completed.

2. Perform operational system tests to verify compliance with Specifications.

3. Test all modes of system operation including:

   a. Functional operation of each field mounted device,
   b. Functional operation of each control circuit,
   c. Supervision function of each initiating, indicating, monitoring, and control circuit,
   d. Perform tests that include originating program and counting material at final outlets, controller inputs, and other inputs,
   e. Signal Ground Test: Measure and report ground resistance at each global equipment pin.
   f. Re-testing: Correct deficiencies, and re-test. Prepare written record tests.
   g. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

4. Schedule tests with at least seven days advance notice of test performance.

K. Integrated Tests with Other Contractors

1. The Contractor shall make equipment available for testing and demonstrating various features specified.

2. The test procedures shall reflect the sequence of tests to be performed.

3. Typical test segments shall include but shall not be limited to the following:

a. Communication Tests shall be performed for the serial or LAN interface to ensure that proper communication can be established between the IP CCTV System equipment and the interfacing systems.
b. Point-to-Point Tests shall be performed on the IP CCTV System equipment to the interfacing systems in order to verify the functionality and correct animation of each I/O point/command including alarm messages.

4. Retesting: Correct deficiencies and retest until total system meets requirements of the Specifications and complies with applicable standards. Prepare written records of tests.

5. Schedule testing with at least seven days advance notice.

## 2130 TRAINING

A. The Contractor is required to conduct end-user training on the Employer's premises, tailored specifically to the Employer's particular requirements in the use, configuration and maintenance of the IP CCTV System equipment and components.

B. Training shall be provided for Technical Staff of the Employer in the Testing, Maintenance and Fault Location of the IP CCTV System.

C. For each product and/or application, the Contractor shall provide a detailed description of the training the Manufacturer will provide.

D. Trainers

1. All training shall be certified training by Manufacturer and trainers shall be approved by the Employer before starting.

2. Engage a factory authorized service representative to explain programming and operation of system and to train Employer's personnel on procedures and schedules for maintaining, programming, operating, adjusting, troubleshooting, and servicing the system.

E. Training Program

1. Scope

a. Training shall be in sufficient scope to ensure that all trainees who complete the program will be certified as capable to operate and/or maintain the equipment, systems, and facilities provided and installed under this Contract, and to ensure a smooth transition between construction and operations activities.

2. Language

a. Training shall be conducted in English and Arabic.

3. Training Aids

   a. Training aids shall include:

      1) Approved Operation and Maintenance (O&M) manual(s) prepared by the Contractor as part of this Contract,
      2) Training manuals, including course outline, basic text of instructions modules, and trainee workbook,
      3) Films, slides, video tape(s),
      4) Charts, models, hand-outs, catalogues,
      5) Samples and other visual,
      6) Written aids to complement instruction.

   b. In addition, spare parts and other special hardware shall be provided to support “hands-on” familiarization with the equipment or systems.

4. Training Manuals

   a. Training manuals shall be provided for each training course covering both the classroom and on-the-job phases.
   b. The organization of the manuals shall follow the same sequence as the course’s scheduled presentation of material, providing such additional background and supplementary information, as a trainee may need to understand the O&M manuals.
   c. There shall be as many Training Manual types as Trainees categories.

5. Training Execution

   a. Scope

      1) Training shall be performed in accordance with an approved training program. All training aids shall be available and approved prior to start of training.

   b. Contents

      1) Training course can be broken down into modules either classroom lecture or ‘On-the-job’ training.
      2) In case of lecture, it is the Employer responsibility to provide the classroom for the duration of the course.
      3) No lecture module should exceed 2 hours time.
      4) “On-the-job” training can be scheduled for entire 8 hour shift.
      5) Handouts must support each module; the collation of the Handouts forms the Training Manual.
      6) Laboratory equipment, spare parts, and mock-up models may be used for theoretical orientation.
      7) However, practical “hands-on” familiarization shall be provided on equipment that is either installed and operable or ready to be installed and capable of being operated. System spares of special hardware items may be used to support “hands-on”

familiarization as long as said spares are returned to inventory in satisfactory condition in accordance with approved procedures.

c. Proficiency

1) At designated intervals each trainee's proficiency levels shall be determined by written, oral and practical performance tests.

d. Operations Training

1) Operators shall be provided with a thorough training in all aspects of system/sub-system operation under both normal and abnormal conditions. This training shall include, but not be limited to:

a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
b) Terminology,
c) Operations theory and interface,
d) Equipment appearance, functions, concepts and operations,
e) Operating mode, practices, and procedures under normal and emergency conditions,
f) Safety precautions,
g) On-the-job operating experience covering all system/sub-system operating functions, activities, and tasks including those associated with degraded operating modes, failure recognition, and recovery processes,
h) Familiarity with content and use of O&M manuals and related reference publications.

e. Maintenance Training

1) Maintenance training shall cover all on-site routine, preventive, and remedial maintenance of the system/sub-system.
2) This training shall include, but not be limited to:

a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
b) Terminology,
c) Operations theory and interfaces,
d) Equipment appearance, layout, functions, concepts and operations,
e) Operating modes, practice, and procedures under normal and emergency conditions,
f) Safety precautions,
g) Use of tools and test equipment,
h) Use of system utilities, diagnostic software and various software tools associated with the system maintenance,
i) Preventive maintenance,
j) Troubleshooting, diagnostics, and testing,
k) Backup and restoration of software/configuration,

l) Assembly and disassembly,
m) Repair and parts replacement,
n) Parts ordering practices and storage,
o) Failure and recovery procedures,
p) System/sub-system cabling,
q) Familiarization with and use of O&M manuals and other reference materials.

f. Administrator Training

1) Administrator course shall be provided so the system administration staff will be able to:

a) Configure the IP CCTV System equipment and the access of all the users,
b) Identify and remedy software faults,
c) Upgrade and implement data and software changes,
d) Production of revised or new displays.

2) This training shall include, but not be limited to:

a) Orientation to provide overview of system/sub-system purpose, configuration, and operations,
b) Terminology,
c) Operations theory and interfaces,
d) Software design and organization,
e) Database structure, generation, and modification,
f) Assembly, compilation, linking, editing, debugging, distributing, testing and integration of program modules,
g) Interface software design,
h) Configuration management and control of software,
i) Backup and restoration of software,
j) Use of system utilities, diagnostic software and various software tools associated with the design, development, and maintenance of the System,
k) Familiarization with and use of O&M manuals and other reference materials.

## 2140 MAINTENANCE AND WARRANTY

A. The CCTV System and all associated equipment in the Contractor's solution shall be warranted by the Contractor and by the Manufacturer to be free of defects in equipment, software, and workmanship for a period of at least two years from the date of Substantial Completion.

B. During the warranty period and any subsequent maintenance agreement, any defective components shall be repaired or replaced at no cost to the Employer.

C. All system maintenance during the warranty period and under any subsequent maintenance agreements shall be performed by the Contractor organization using personnel employed full time by the Contractor and at no additional cost to the Employer other than those charges stipulated to maintain the warranty.

# 276 ACCESS CONTROL SYSTEM

## 276:A GENERAL

A101 GENERALLY electrical work is to be in accordance with the requirements of sections 201, 202 and 203 of the Specifications.

A151 DESCRIPTION OF WORK: installation of a complete access control system.

The system includes the following:

Proximity card readers, magnetic door contacts, electric strikes, electromagnetic locks,

Access Control Panels (ACP) for control of a specific number of readers,

Monitoring, Management and Control System for the Security and Access Control System implemented for the building,

Power supply cabling and installation accessories.

A161 DEFINITIONS

ACP: Access Control Panel.

BMS: Building Management System.

CCTV: Closed Circuit Television.

FAS: Fire Alarm System.

GUI: Graphical User Interface.

HTTP: Hyper Text Transfer Protocol.

HMI: Human Machine Interface.

IB: Interface Box.

IP: Internet Protocol

MTTR: Mean Time To Repair.

MTBF: Mean Time Between Failures.

PKI: Public Key Infrastructure.

SACS: Security and Access Control System.

SCN: Structured Cabling Network.

UPS: Uninterrupted Power System.

XML: Extensible Mark-up Language.

## A201 REGULATIONS AND STANDARDS:

A. Rules

1. The supply shall be conformed to requirements of referenced industry standards, applicable sections.

2. The supply shall be compliant with Local Requirements, applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.

B. Standards

1. System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC)

   a. ISO/IEC 11801: latest edition regarding Information Technology and Generic Cabling for Customer Premise.
   b. ISO 14443 A or B Standard.
   c. EIA/TIA 568, Commercial Building for Telecommunication Wiring Standard.
   d. EIA/TIA 569, Commercial Building for Telecommunication Pathways and Spaces.
   e. EIA/TIA 606 for Telecommunications Infrastructure: This document provides the user of this document with guidelines and choices of classes of administration for maintaining telecommunications infrastructure.
   f. EIA/TIA 607 Commercial Building Grounding (Earthling) and Bonding Requirements for Telecommunications (ANSI/J-STD-607-A-2002).
   g. IEC 60754-1 & 2 Test on Gases Evolved During Combustion of Materials from Cables and Test on Gases Evolved During Combustion of Electric Cables.
   h. IEC 61034-1 & 2 Test and Measurement of Smoke Density of Cables Burning under Defined Conditions.
   i. IEC 60331 Part 11& 12, Tests for Electric Cables under Fire Conditions.
   j. IEC 60332 Tests on Electric Cables under Fire Conditions.
   k. IEC 60364-1 Electrical Installations of Buildings, Fundamental Principles, Assessment of General Characteristics, Definitions.

2. IEEE: Institute of Electrical and Electronics Engineers

    a. Comply with the latest issues of material and test standards which have been developed and published by the Institute of Electrical and Electronics Engineers (IEEE) 802 Working Group (WG) data communications.

3. ISO: International Standardization Organization:

    a. It promotes the development of international standardization with scientific, technological and economic activities.
    b. The Technical Committee 97, Information Processing, developed a seven-layer communications reference model that allows multiple protocol and multiple vendor environments to interconnect and operate with one another.

4. Comply, as often as possible, with both ITU-T (International Telecommunications Union) recommendations and US standards. When standards are not compatible in both Europe and US (e.g. telecom interfaces SDH STMx vs. SONET OCx) detailed compatibility and interface availability shall be provided.

5. Building Industry Consulting Service International (BICSI):

    a. Publishes the Telecommunications Distribution Methods Manual (TDMM), which is a comprehensive collection of accepted practices in the design and methodology of communications systems, and the Electronic Safety and Security Design Reference Manual (ESSDRM), which is a comprehensive collection of accepted practices in the design and methodology of electronic security systems. BICSI provides a competency examination for the professional designation as a registered Communications Distribution Designer.
    b. This manual should be used as a reference only.

6. Network Equipment Building System (NEBS):

    a. Level 1, Level 2, and Level 3 are applicable to these section.

C. Precautions:

1. The above list is a partial list issued from standard organization. Additional consideration may be required to provide protection of communications equipments, data processing equipment and protection of data from intrusion, induced noise or other events that can disrupt vital operation.

A301 TESTS: equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Engineer before dispatch of equipment to site.

A401 EQUIPMENT DATA: submit complete technical data including manufacturer's catalogues and specification, system description including operational aspects, system features and components.

A501 SHOP AND CONSTRUCTION DRAWINGS: submit drawings for approval including, but not limited to, the following:

Locating of devices as shown on Drawings.

Layout drawings showing location of devices, doors, controllers, cables and containment, etc.

Diagrams for cable management system.

System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system.

Wiring Diagrams: they shall show typical wiring schematics, including typical installation details, doors hardwiring scheme, dimensions, etc.

Detail system schematic for each area.

A601 PERFORMANCE REQUIREMENTS

A. Security and Access Control System Performance

1. Distributed Processing: The system shall be a fully distributed processing system, so that information, including time, date, valid codes, access levels, and similar data, is downloaded to Controllers so that each Controller makes access control decisions for that location. Do not use intermediate Controllers for access control. If communications to server are lost, all Controllers shall automatically buffer event transactions until communications are restored, at which time buffered events shall be uploaded to the server.

2. Server shall provide operator interface, interaction, display, control, and dynamic and real-time monitoring. Server shall control system networks to interconnect all system components, including workstations and field-installed Controllers.

3. Field equipment shall include Controllers, sensors, and controls. Controllers shall serve as an interface between the Server and sensors and controls. Data exchange between the Server and the Controllers shall include down-line transmission of commands, software, and databases to Controllers. The up-line data exchange from the Controller to the Server shall include status data such as intrusion alarms, status reports, and entry-control records. Controllers are classified as alarm-annunciation or entry-control type.

4. System Response to Alarms:

    a. Field device network shall provide a system end-to-end response time of 1 second, or less, for every device connected to the system.
    b. Alarms shall be annunciated at the Server within 1 second of the alarm occurring at a Controller or device controlled by a local Controller, and within 100 ms if the alarm occurs at the Server.
    c. Alarm and status changes shall be displayed within 100 ms after receipt of data by the Server.
    d. All graphics shall be displayed, including graphics-generated map displays, on the console monitor within 3 seconds of alarm receipt at the security console. This response time shall be maintained during system heavy load.

5. Error Detection:

    a. A cyclic code error detection method shall be used between the Controllers and the Server, which shall detect single- and double-bit errors, burst errors of eight bits or less, and at least 99 percent of all other multi-bit and burst error conditions.
    b. Interactive or product error detection codes alone will not be acceptable.
    c. A message shall be in error if one bit is received incorrectly.
    d. System shall re-transmit messages with detected errors. A two-digit decimal number shall be operator assignable to each communication link representing the number of re-transmission attempts.
    e. When the number of consecutive re-transmission attempts equals the assigned quantity, the Server shall print a communication failure alarm message. System shall monitor the frequency of data transmission failure for display and logging.

6. Data Line Supervision:

    a. System shall initiate an alarm in response to opening, shorting, or grounding of data transmission lines.

7. Expansion Capability:

    a. The system shall have provision to increase the number of security access points in the future by 25% above those indicated without adding any internal or external components or main cable conductors and respective raceways.

8. The Contractor shall guarantee that operation and maintenance by the Employer’s personnel with proper training shall enable the SACS to fulfill the following performance requirements:

    a. Availability: 99.8 % over 30 floating days for the SACS Server.
    b. Card Reader (CR): one CR out of service shall not occur more than 5% of the time.

c. MTTR: 30 minutes maximum.
d. MTBF of CR and Access Control Panel (ACP): 50,000 hours minimum.

9. For servers and workstations, the Contractor's choice shall be submitted to the Engineer for approval, to ensure proper reliability.

10. In order to achieve the requested MTTR and MTBF, modular conception and quick interchange of modules is required for SACS components such as CR and ACP.

11. ACP: in local mode, the maximum time between a device activation and the real unlock of the access shall be less than 1.5 seconds.

12. Main SACS Server:

a. The main SACS server shall be installed in the Server Room located in the Cargo and Container Building, ground floor.
b. The maximum time between a door alarm appearance or an information elaboration by a ACP and the display on the HMI, shall be less than 3 seconds.
c. The maximum time between a screen display request by a switch push, with the mouse, or an alarm appearance and the total display on the screen shall be less than 2 seconds.
d. The complete loading of the white list (case of a maximum configuration with 1,000 ACP) in all the ACP connected to the Server shall be ended in less than 10 minutes.
e. A configuration element (creation/modification/deletion of right for a badge, exploitation planning, etc.) shall be taken into consideration by all the ACP in less than 1 minute.
f. A server dysfunction must not modify the proper functioning of the other elements of the system. For the restoring of the main SACS Server, all the procedures and the updating of the data must be totally automatic (no manual intervention).
g. All the information not sent during the dysfunction shall be sent during the restoring.
h. The application initialization (cold start) shall be completed in less than 30 minutes.

B. Dimensions Requirements

1. Main SACS Server Requirements:

a. More than 1,000 ACP could be connected without performance loss (response time).
b. The historical database shall be able to memorize all the events during 24 months (on a base of 1,000 events/day and by access).
c. The display of a historical state shall take less than 5 seconds (searching with 3 keys of selection).

2. Operators' Workstations:

   a. The SACS system shall be able to have unlimited operators' workstations with all features of the main supervision workstation.

C. Working Safety

1. ACP:

   a. The equipment availability must be of 98%.
   b. ACP shall be able to manage the loading by the remote server or, locally, in independent mode, without information loss.
   c. A dead server or any problem or change of configuration shall not disturb the ACP operation in the system.
   d. In case of electrical loss, configuration and memorized data have to be saved. When the power comes back, the ACP must be able to operate immediately without any human intervention.

2. Events Avalanche Management:

   a. Events avalanche must not disturb the system operation.
   b. Events avalanche shall be managed by the ACP and the main SACS Server.
   c. Events avalanche must not be responsible of any information loss.

## A651 QUALITY ASSURANCE

A. Requirements

1. The Contractor shall implement the ISO 9001 quality assurance system.

2. This system shall comprise all the participants to the Contract within the Contractor's teams and its sub-contractors.

3. The Quality Assurance Plan shall be based on quality manuals of the Contractor and sub-contractors.

4. The Contractor shall nominate from the beginning of the Project, the person in charge of quality assurance of the whole project, who is directly linked to the Project Director.

5. The Contractor shall establish from the beginning of the project, the Quality Assurance Plan based on Contractor's quality system that should define:

   a. Scope of Quality Assurance Plan, with conditions of validity and revision,
   b. Organization retained for the Project with sub-contractors list,
   c. The quality plans of the Contractor.

B. Manufacturer Qualifications

1. A firm specialized in providing security and access control materials, integrated supervision interfaced with, but not limited to, the following systems: CCTV, FAS, etc. to that indicated for this Project and with a record of successful in-service performance.

2. Manufacturer's system shall be a standard "off-the-shelf" package utilizing the latest hardware and software technology.

3. Any major system development efforts necessary to meet specified requirements are unacceptable.

4. Even if this system is a new concept, it shall not require a huge development and shall be based on existing and proven technologies.

C. Maintenance Center

1. The Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, spare parts and emergency maintenance and repairs for overall system at Project site with eight hours maximum response time.

D. Installer Qualifications

1. An experienced Installer who is an authorized representative of the equipment Manufacturer for both installation and maintenance of Manufacturer's equipment, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance.

E. Materials and Workmanship

1. Materials and workmanship shall comply with the latest issue of all industry standards, publications, or regulations referenced in this Section, including the following as applicable:

    a. Regulations and Standards: System components, parts and installation are to comply with the corresponding recommendations of the Electronic Industries Association (EIA), and the International Electro-technical Commission (IEC).
    b. Compliance with Local Requirements: Comply with applicable local regulations and code requirements of authorities having jurisdiction. These will have precedence over other codes and standards indicated, unless otherwise approved by the Engineer, in writing.
    c. Conform to requirements of referenced industry standards, applicable sections.

F. Source Limitations

1. Obtain system components from one Manufacturer who shall assume responsibility for system components and for their compatibility.

## A701 WARRANTY

A. Special Warranty

1. Manufacturer’s Warranty:

a. Provide written warranty, signed by Manufacturer and Installer agreeing to replace system devices, software and equipment that fail in material or workmanship within the specified warranty period.
b. The Manufacturer or factory-authorized agency shall maintain a service center capable of providing training, spare parts and emergency maintenance and repairs for overall system at Project site with eight hours maximum response time.

2. Installer Qualifications:

a. An experienced Installer who is an authorized representative of the equipment Manufacturer for installation and maintenance of Manufacturer’s equipment hardware and software, and who has completed system installations similar in design and extent to that indicated for this Project, with a record of successful in-service performance.

3. Materials and workmanship shall conform to the latest issue of all industry standards, publications, or regulations referenced in “Regulations and Standards” Article.

4. Source Limitations:

a. Obtain system components from one manufacturer who shall assume responsibility for system components and for their compatibility.

B. Experimental Period

1. There shall be an experimental period of 90 days after successful testing and commissioning of the system, but before issuance of substantial completion certificate. During this period, the Contractor shall undertake supervision and responsibility for operation of the system under actual site conditions. If any malfunctioning or anomaly is noted on the system during this period, it shall be attended to immediately. The experimental period will restart automatically from the date of clearing such troubles and start normal operation.

2. During the experimental period, the Contractor shall undertake supervision and responsibility for operating the system.

3. After the satisfactory completion of this period, the System is to be taken over by the Employer, as per Contract Conditions, whereby the warranty period is to commence.

C. Warranty Period

1. Two (2) years from the date of Substantial Completion of the SACS.

2. During the guarantee period, the Contractor shall provide, at its own cost, all required spare parts needed to replace existing components unless it is proved that the component to be replaced was damaged by abuse.

D. Manufacturer Product Performance

1. The Contractor shall provide a Manufacturer endorsed and backed extended 10-years product, performance, application, and labor warranty which shall:

a. Warrant against defects in materials and workmanship (extended product warranty) for a period of ten (10) years.
b. Warrant that all cabling components of the installed system will meet or exceed the specifications of section 265 of this Specification.
c. Warrant that the system shall be application independent and shall support both current and future applications that use the TIA/EIA 568B or ISO/IEC 11801 component and link/channel specifications for cabling (application warranty), for a period of 10 years.
d. Warrant that all labor attributable to and required by the above shall be supplied at no cost to the Employer for a period of 10 years.

## A751 COMMISSIONING

A. Purpose

1. The purpose of the commissioning phase is to check the equipment according to its elementary function.

2. During this phase the equipment is powered and the automation and networking are gradually integrated layer by layer.

3. Mock-up of all types of doors shall be provided in order to verify all the requested functionalities (To be defined with the Employer).

B. Tests: Those tests are divided into 2 sub-phases:

1. Preliminary Testing:

a. Mechanical:

1) Mechanical tests,
2) Calibration of the sensors.

b. Automatism / Electrical:

1) Powering tests with and without electricity,
2) Control of input/output,
3) Control of the safety measure either personal or material,
4) Test of local mode operation.

c. Network / Software Tests:

1) Test of the network,
2) Test of the supervision workstation user interface,
3) Test of the portable terminal user interface.

2. Test of the System:

a. The tests performed during this phase are performed with and without loading conditions.

1) Testing the crippled mode (Safe shut down consecutive to loss of energy, etc.).

## A801 MAINTENANCE

A. Maintenance Service

1. The Manufacturer or factory-authorized agency shall maintain a service center capable of providing spare parts and emergency maintenance and repairs for overall system at Project site with eight hours maximum response time.

B. Repair Time or MTTR

1. The MTTR shall not exceed 30 minutes. The MTTR shall include the diagnostic time, active repair/replacement time and the adjustment/testing time on site, but shall exclude the response time.

2. The Contractor’s response time shall not exceed 1 hour. The response time is defined as the time that elapses between the reporting of a fault and the maintenance personnel arriving at where the faulty equipment is located.

C. Maintenance Performance Data

1. The Contractor shall be committed to the three main sizing data of maintenance:

a. Annual number of hours of preventive maintenance,
b. Annual number of hours of corrective maintenance,
c. Average annual cost of spare parts (average based on ten years).

## A851 SPARE PARTS AND EXTRA MATERIALS

A. Generalities

1. The Contractor shall provide the Manufacturer recommended spare parts for all major components in the system for two years fault free operations.

2. However a minimum of 2% peripherals of each type installed, but not less than one from each type, shall be included in the deliverable irrespective of Manufacturer recommendation.

B. Spare Parts

1. During the guarantee period, the Contractor shall provide, at his own cost, all required spare parts needed to replace existing faulty components unless it is proved that the component to be replaced was damaged by abuse, the replacements of the faulty components with a new one shall be done within three days maximum from the date of the faults happening.

C. Extra Materials

1. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels clearly describing contents.

2. SACS Devices:

   a. The quantity of extra materials to be supplied by the Contractor will be proposed and quoted by the Contractor at the tender stage.
   b. Dedicated Card Readers shall be provided (as an option) at selected locations (the exact locations may be agreed during construction stage) for Time and Attendance purposes.

3. Test Equipment:

   a. Provide, together with an itemized list, all test equipment and tools required for routine maintenance, safety checks, and equipment repair.
   b. Deliver test equipment and tools at the same time as the system equipment.

## A901 APPROVED MANUFACTURERS: obtain the system from one of the following:

Honeywell (U.S.A.)

GE Security (U.S.A.)

Lenel (U.S.A.)

or other equal and approved.

PRODUCTS AND SYSTEMS

## 276:X ACCESS CONTROL EQUIPMENT

### 276:X1 SYSTEM DESCRIPTION AND OPERATION

X101 SYSTEM DESCRIPTION: system is to comprise of a programmable, microprocessor-based controller, governed by proximity type card reader, electric door locks and magnetic contacts located at doors as shown on drawings. System to be coordinated with the architectural door hardware.

### 276:X2 SACS SOFTWARE SPECIFICATION

X210 SOFTWARE GENERALITIES:

1. It shall be designed specifically for security applications and shall provide for polling and demand requests to monitor status, processing alarms according to priority, controlling and processing communications with operator workstations, and synchronizing all system activity.

2. System software shall permit point additions and deletions, activation and deactivation, and system reprogramming by authorized personnel.

3. The software license shall not be limited and shall be opened for any number of users.

4. The software application shall be working on popular and user-friendly platform.

5. Application software shall provide the following operating features:

    a. Door-by-door basis; lock or unlock doors according to a day and time schedule or an event-initiated program.
    b. The software shall allow manual control of selected inputs, outputs and groups of outputs. Manual control shall include pulse and energize/de-energize options for output points and shunt/unshunt options for input points.
    c. Door-by-door and individual cardholder basis; permit access to a limited group of cardholders according to a day and time schedule, operator command, or an event-initiated program.
    d. Provide for the creation of up to 8 time zones, 50 time and day schedules, with up to 30 holidays assignable to each schedule.
    e. Provide for an individually and adjustable alarm shunt time delays for entry and exit for each door.

f. Provide the capability to lockout all users for a certain number of minutes after a certain number of invalid logs on attempts.
g. Modify access control privileges of individual cards.

6. It shall include, validation based on time of day and day of week, holiday scheduling, site code verification with card validation override, image storage and retrieval of cardholder photographs, and access validation based on positive verification of card, and card recognition.

7. The method of communication from remote locations to the central components shall be transparent to the user.

8. Flexibility: Software will be flexible and source code will be available to allow the maintenance operator to reconfigure the system at site.

## X220 SOFTWARE MAIN FUNCTIONALITIES:

1. Anti-Pass Back Functionality (APB):

   a. System shall have global and local anti-pass back features, selectable by location. System shall support hard and soft anti-pass back.
   b. Hard anti-pass back: Once a credential holder is granted access through a reader with one type of designation (IN or OUT), the credential holder may not pass through that type of reader designation until the credential holder passes though a reader of opposite designation.
   c. Soft anti-pass back: Should a violation of the proper IN or OUT sequence occur, access shall be granted, but a unique alarm shall be transmitted to the control station, reporting the credential holder and the door involved in the violation. A separate report may be run on this event.
   d. Timed anti-pass back: The system prevents an access code from being used twice at the same device (door) within a user-defined amount of time.
   e. The anti-pass back schemes shall be definable for each individual door.
   f. The Master Access Level shall override anti-pass back.
   g. System shall have the ability to forgive (or reset) an individual credential holder or the entire credential holder population anti-pass back status to a neutral status.

2. Operator Authentication:

   a. Multilevel Password Protection: Control operator access to system controls through 10 password-protected operator levels. System operators and managers with appropriate password clearances shall be able to change operator levels for operators.

b. Software Tamper:

1) Annunciate a tamper alarm when unauthorized changes to system database files are attempted. Three consecutive unsuccessful attempts to log onto system shall generate a software tamper alarm.
2) Annunciate a software tamper alarm when an operator or other individual makes three consecutive unsuccessful attempts to invoke functions beyond their authorization level.
3) Maintain a transcript file of the last 5,000 commands entered at the each server to serve as an audit trail. System shall not allow write access to system transcript files by any person, regardless of their authorization level.
4) Allow only acknowledgment of software tamper alarms.

c. A minimum of 15 passwords shall be available with the system software. System shall display the operator's name or initials in the console's first field. System shall print the operator's name or initials, action, date, and time on the system printer at login and logoff.
d. The password shall not be displayed or printed.
e. Each password shall be definable and assignable for the following:

1) Commands usable,
2) Access to system software,
3) Access to application software,
4) Individual zones that are to be accessed,
5) Access to database.

3. System software shall provide the following reports:

a. Alarm history consisting of acknowledged alarms.
b. Badge history including access attempts by valid, invalid, lost, and suspended badges.
c. Operator history consisting of database changes and log-ins by operators.
d. A query functions to allow selected data to be sorted on not less than 3 selection criteria.

4. Badge Designing Function:

a. A badge designing function is to be provided to retrieve picture and chose card background.
b. The software shall be able to take picture and arrange it in the database.

5. Operator's Command:

    a. Tasks that are executed by operator's commands shall include the following:

        1) Acknowledge Alarms: Used to acknowledge that the operator has observed the alarm message.
        2) Place Zone in Access: Used to remotely disable intrusion alarm circuits emanating from a specific zone. System shall be structured so that console operator cannot disable tamper circuits.
        3) Place Zone in Secure: Used to remotely activate intrusion alarm circuits emanating from a specific zone.
        4) System Test: Allows the operator to initiate a system-wide operational test.
        5) Zone Test: Allows the operator to initiate an operational test for a specific zone.
        6) Print reports.
        7) Change Operator: Used for changing operators.
        8) Others to be configured.

6. Card Expiry Function: Allows readers to be configured to deactivate cards when a card is used at selected devices.

7. Reconfirmation:

    a. Any important activation of important control functions shall be subject to a reconfirmation.

8. Administration:

    a. This software is used by an authenticated administrator in order to mainly:

        1) Look after the whole access control system,
        2) Remotely configure equipment (local intelligent panels, for instance),
        3) Download rules or personal profiles into the controllers,
        4) Receive alarms from the different components of the Security and Access Control System (ACP, Card Readers, doors, etc.),

    b. Entry-Control Commands:

        1) Lock (secure) or unlock (open) each controlled entry and exit up to four times a day through time-zone programming.
        2) Arm or disarm each monitored input up to four times a day through time-zone programming.
        3) Enable or disable readers up to twice a day through time-zone programming.

4) Enable or disable cards up to four times per day per entry point through access-level programming

c. Command Input Errors:

1) Show operator input assistance when a command cannot be executed because of operator input errors. Assistance screen shall use plain-language words and phrases to explain why the command cannot be executed. Error responses that require an operator to look up a code in a manual or other document are not acceptable. Conditions causing operator assistance messages include the following:

a) Command entered is incorrect or incomplete.
b) Operator is restricted from using that command.
c) Command addresses a point that is disabled or out of service.
d) Command addresses a point that does not exist.
e) Command is outside the system's capacity.

d. Authentication:

1) The software shall provide authentication of the system administrators using multi-level password protection, with user-defined operator name/password combinations.
2) Name/password log-on shall restrict operators to selected areas of the program.
3) Provide the capability to lockout all users for a user-definable number of minutes after a user-definable number of invalid log-on attempts.

e. Alarms:

1) When an access alarm occurs, the operator in front of the workstation reset the alarm once the door is known.
2) Security personnel shall go to the concerned door and check the status of the door and report to the operator who initialized the inspection of the door in alarm.

3) Alarm System Setup:

a) Assign manual and automatic responses to incoming point status change or alarms.
b) Automatically respond to input with a link to other inputs, outputs, operator-response plans, and unique sound with use of WAV files, and maps or images that graphically represent the point location. A direct zoom shall pop up on to the screen.
c) 80-character message field for each alarm.

d) Operator-response-action messages shall allow message length of at least 65,000 characters, with database storage capacity of up to 30,000 messages. Setup shall assign messages to access point, zone, and sensor. This can be configured.
e) Secondary messages shall be assignable by the operator for printing to provide further information and shall be editable by the operator.
f) Allow secondary messages with a field of lines and characters each.
g) Store the most recent 1,000 alarms for recall by the operator using the report generator.

f. System Programming:

1) It shall be user friendly, and capable of being accomplished by personnel with no prior computer experience.
2) The programming shall be MENU driven and include on-line "Help" function or "Tutorial" information, as well as online data entry examples.
3) The system shall provide both supervised and non-supervised alarm point monitoring. Upon recognition of an alarm, the system shall be capable of switching CCTV cameras that are associated with the alarm point in less than 300 ms, where applicable.
4) The system shall be capable of arming or disarming alarm points both manually and automatically, by time of day, and day of week.
5) The SACS Server shall be designed for full security and access control functions including configuration, graphics, and cardholder database.

g. Languages:

1) The languages used shall be English and Arabic.
2) Engineering information could be provided in English and Arabic.

9. Discreet Alarm:

a. Discreet alarm system shall be monitored on the supervision.
b. A special symbol shall be used to represent the discreet alarm push button.

## X230 GRAPHICAL USER INTERFACE:

1. The Graphical User Interface (GUI) shall provide operator interface:

    a. Inputs in system shall have two icon representations, one for the normal state and one for the abnormal state.
    b. When viewing and controlling inputs, displayed icons shall automatically change to the proper icon in order to display the current system state in real-time. Icons shall also display the input's state, whether armed or bypassed, and if the input is in the armed or bypassed state due to a time zone or a manual command.
    c. Outputs in system shall have two icon representations, one for the secure (locked) state and one for the open (unlocked) state.
    d. Icons displaying status of the I/O points shall be constantly updated to show their current real-time condition without prompting by the operator.
    e. The operator shall be able to scroll the list of I/Os and press the appropriate toolbar button, or right click, to command the system to perform the desired function.
    f. Graphic maps or drawings containing inputs, outputs, and override groups shall include the following:

        1) Database to import and store full-color maps or drawings and allow for input, output, and override group icons to be placed on maps.
        2) Maps to provide real-time display animation and allow for control of points assigned to them.
        3) System to allow inputs, outputs, and overrides groups to be placed on different maps.
        4) Software shall allow changing the order or priority in which maps will be displayed.

    g. General Schematic Diagram:

        1) General schematic diagram of the SACS architecture shall be available showing all items of the system.
        2) In case of any default, the faulty item shall be highlighted for a better operator understanding.

2. The GUI shall provide color graphics:

    a. Editor shall allow the generation of custom dynamic graphics for graphical representation of the card access system.
    b. The editing menu shall provide help menus for selecting graphics, choosing colors, copying previous graphics, and deleting data points.
    c. Each type of door should be different as a symbol and/or color and be dynamic upon state.
    d. Information on the color graphic display shall be dynamic and automatically updated.

e. Provide the capability of linking high level maps with lower level (more detailed) maps and vice-versa.
f. The Contractor shall propose an essential background for SACS showing the essential information for the user to know where he is.

3. Display Graphics:

a. Used to display any graphic displays implemented in the system. Graphic displays shall be completed within 3 (three) seconds from time of operator command.
b. “Help” request within the system operation:

1) Included in main menus.
2) Provide unique, descriptive, context-sensitive help for selections and functions with the press of one function key.
3) Provide navigation to specific topic from within the first help window.
4) Help shall be accessible outside the applications program.

c. Reports shall have the following options:

1) On screen view.
2) Print to System Printer: Include automatic print spooling and “Print To” options if more than one printer is connected to system.
3) “Save to File” with full path statement.
4) System shall have the ability to produce a report indicating status of system inputs and outputs or of inputs and outputs that are abnormal, out of time zone, manually overridden, not reporting, or in alarm.

4. Display of Elements:

a. All Elements regarding Security and Access Control System shall be represented on the layout of the supervision. These elements are at least:

1) Card Readers,
2) ACP,
3) Server,
4) The Security Zoning including Exit Paths.

b. Depending on the password, it shall be possible to change and configure features from any workstation.

X240 CARD ENROLLMENT SOFTWARE:

1. Special enrollment software shall be provided. A dedicated workstation shall be proposed for this purpose.

2. Specifications and enrollment functionalities and procedure shall be provided for the Employer approval. Cardholders enrollment planning shall be provided for the Employer approval.

3. Special security treatment shall be provided, such as:

    a. Key Encryption for HF transmission during enrollment,
    b. Read and Write Key in operation mode,
    c. Read and Write Key for data storage in the Smart Card.

4. The enrollment station shall not have alarm response or acknowledgment functions.

5. The SACS software shall provide for multiple password-protected access levels. Database management and modification functions shall require a higher operator access level than personnel enrollment functions.

6. The program shall provide means to disable the enrollment station when it is unattended to prevent unauthorized use.

7. The program shall provide a method to enter personnel identifying information into the entry-control database files through the enrollment station. Allow entry of personnel identifying information into the system database using menu selections and data fields. The data field names shall be customized during setup to suit user and site needs.

8. Cardholder Data: Provide 99 user-defined fields. System shall have the ability to run searches and reports using any combination of these fields. Each user-defined field shall be configurable, using any combination of the following features:

    a. CARD MAPPING: Determines a specific format that data must comply with.
    b. REQUIRED: Operator is required to enter data into field before saving.
    c. UNIQUE: Data entered must be unique.
    d. DEACTIVATE DATE: Data entered will be evaluated as an additional deactivated date for all cards assigned to this cardholder.
    e. NAME ID: Data entered will be considered a unique ID for the cardholder.

9. Personnel Search Engine: A report generator with capabilities such as search by last name, first name, group, or any predetermined user-defined data field; by codes not used in definable number of days; by skills; or by seven other methods.

10. Multiple Deactivate Dates for Cards: User-defined fields to be configured as additional stop dates to deactivate any cards assigned to the cardholder.

11. Visitors Badging Assignment:

    a. Provide for and allow an operator to be restricted to only working with visitors. The visitor badging subsystem shall assign credentials and enroll visitors. Allow only access levels that have been designated as approved for visitors.
    b. Provide an automated log of visitor name, time and doors accessed, and whom the visitor contacted.
    c. Allow a visitor designation to be assigned to a credential holder.
    d. Security and Access Control System shall be able to restrict the access levels that may be assigned to credentials that are issued to visitors.
    e. Allow operator to recall visitors' credential holder file, once a visitor is enrolled in the system.
    f. The operator may designate any reader as one that deactivates the credential after use at that reader. The history log shall show the return of the credential.
    g. System shall have the ability to use the visitor designation in searches and reports. Reports shall be able to print all or any visitor activity.

12. Card Mapping Requirements:

    a. The mapping of the card shall store, at least, the following information:

        1) Serial number of the card (hardware),
        2) Name and ID folder of the card holder,
        3) Validity of the card,
        4) Pin code number,
        5) Anti-pass back writing zone,
        6) Working service or group,
        7) Key encryption for read and write using 3DES encryption,
        8) Other free writing spaces that shall be used at any time with specific W/R key.

    b. All W/R keys are the proprietary of the Employer and shall be held in a secret place on different hardware (at least 2).

X250 TECHNICAL SPECIFICATIONS:

1. Operating System: At least Windows XP; to be confirmed by the Employer.

2. Specific Developments:

    a. No hard specific development is allowed for the software.
    b. The software is to be proven and installed for other project of the same size.

3. Software and GUI and HMI background of the whole controlled area shall be compliant with at least WMF, DWG, JPEG, and BMP and shall take into consideration the Architectural Drawings and layout of the controlled area. Proposal shall be provided to the Employer for his approval and agreement.

## 276:X3 OPERATION DESIGN AND COMPONENTS

### X301 GENERAL

1. Servers, PC workstations, printers, etc. shall be from one of the most reputed PC Manufacturers and the Contractor's choice shall be coordinated with the Employer.

### X305 WORKSTATIONS

1. Real-time Functions:

    a. The color monitor and keyboard for each workstation shall display real-time data, allow operator's commands, and report system activity. Monitors shall be at least 17" TFT screen. It shall be designed to work 24 hours a day.
    b. The host workstation shall function as the system programmer's and system operator's workstation, for entering and editing the system database, entering operating software, and monitoring the operation of all system functions.

2. Operator Workstation: In order to provide the best up-to date equipment at the lowest price and to manage the maintenance at the best level, the Contractor shall specify their requirements to the Employer's IT department.

3. Alarm Output:

    a. The output of alarm displays shall depend upon the relative priority of each alarm.
    b. The system shall automatically prioritize alarm displays.

4. Format: The format shall include a dedicated and protected area of the viewing screen for the current date and time.

5. Advisory Messages: Each workstation monitor shall display system advisory messages upon hardware malfunction or restoration in a dedicated and protected area of the viewing screen.

6. Power Supply: Provided from the UPS system in the building in order to allow normal continuous operations for 15 minutes or until the emergency generators are online, whichever occurs first.

7. Access Rights: The usage of workstation for any function shall be purely based on access rights of the user defined by his password.

8. Flexibility: Workstations shall be fully flexible. Their function can be adapted at any time depending on the authorization password.

9. Communication: Communication between servers and workstations must use a PKI mechanism and allows HTTPS protocol.

## X310 DATA AND ALARM LASER PRINTER

1. Printer:

   a. A laser printer shall be provided for each primary and secondary workstation for hard copy alarm printouts and system malfunction report.
   b. The laser printer output shall be the latest version on the market.
   c. All printers shall be heavy duty, suitable for 24 hours operation.

2. Printer Characteristics:

   a. Each printer shall have a buffer memory to permit operation at communication rates up to 10 Mbps.
   b. Printers shall communicate over the latest interface.
   c. The minimum characteristics will be:

      1) Format: A4 and A3.
      2) Printing speed: 50 p/min (B/W), 15 p/min (color).
      3) Resolution: 600 x 600 (B/W), 500 x 500 (color).
      4) Drawer: 100 sheets.
      5) Additional drawer of 500 sheets.

## X315 CARD PRINTER

1. Card Printer:

   a. The card printer shall be provided for the enrollment workstation for printing out facial of the card regarding the mapping in the SACS supervision.
   b. The printer output shall be the latest version on the market.

2. Printer Characteristics:

   a. The printer shall be compatible with all cards ISO standards related to physical and temperature requirements.
   b. The printer shall be of double-sided printing with multiple layers.
   c. The printing rate shall be, at least, 5 cards/minute.

## X320 ENROLLMENT CAMERA

1. Enrollment Camera:

    a. The enrollment camera shall be provided for the enrollment workstation.
    b. It shall be directly connected to the enrollment workstation using Ethernet or the serial port of the station.

## X325 COMMUNICATION NETWORK

1. Communication:

    a. All communication between the host workstation, secondary workstations, and the access control panels shall be an IP network, running over an Ethernet, in accordance with section 266 of this Specification.

2. Data Transmission: The data transmission rate between the workstations and the servers shall be bi-directional using TCP/IP VLAN network.

## X330 SERVER

1. Redundancy:

    a. The system shall be based on two servers (one being hot redundant on the other one), and several clients.
    b. Communication between the servers and the clients' workstations must be based on TCP/IP and HTTPS, using any standard Internet browser.

2. Hardware Fault Tolerance: Redundant hardware design shall include either Dual-Modular Redundancy (DMR) or Triple-Modular Redundancy (TMR) models to protect users' applications from component outages.

3. Software Availability:

    a. The server must prevent outages and minimize downtime related to software issues.
    b. Integrated Service Technology: The Server shall provide proactive service to feature system detect emerging problems early to help keep the system and application online during troubleshooting, repairs, or upgrades.

4. Interfaces with the Server shall be taken into consideration at the design stage and discussed with the Employer.

5. Furniture:

    a. In order to provide the best up-to date equipment at the lowest price and to manage the maintenance at the best level, the Contractor shall provide his requirements to the Employer's IT department.
    b. The minimum characteristics will be:

        1) Dual-processor with highest speed available on the local market.
        2) Highest available RAM capacity.
        3) 2 disks RAID 1, highest available GB capacity.
        4) External Controller RAID.

## X335 CARD AND CHIPSET

1. The amount of required cards will be given at a later stage.

2. Standard: ISO 14443 type A/B.

3. Card Format: Compliant with ISO 7810, 7811, and 18555.

4. Reading Distance: At least 5 cm; the Contractor shall be responsible to eliminate all the effect and the influences of the metallic supports affecting the reading distance of the Card Reader.

## X340 ACCESS CONTROL PANEL FUNCTIONALITIES

1. Functionality:

    a. The Access Control Panel (ACP) is a microprocessor-based device, which supports the operation of card access and security monitoring hardware.
    b. Each ACP shall be capable of independent operation should a loss of communication with the workstations occur.
    c. Each ACP shall support the operation of access control card readers, electric door locks, door and other digital alarm devices, and door exit devices.
    d. Modular expansions shall be available for one (1) to four (4) supplementary access.
    e. The number of alarm transactions and access transactions a ACP shall be capable to store shall be mentioned by the Contractor.

2. Required Software:

    a. Required software shall be resident in the ACP.
    b. This shall include approved card access codes for each reader and the door unlock times for each door connected to the ACP.

c. Approved card codes and door unlock times may be updated through the workstations.
d. The ACP software shall allow direct control of the output relays and input status ports through the workstations.

## X345 ACCESS CONTROL PANEL SPECIFICATIONS

1. Technical Features:

a. The ACP shall provide the minimum features rated below:

1) Ambient Operating Temperature: -10° C to 60° C.
2) Ambient Humidity: 10% RH to 90% RH (non-condensing).

b. The ACP shall be communicating through Ethernet TCP/IP protocol using unique MAC address for central configuration.
c. Allow for redundancy for essential controllers.
d. Controllers shall be modular, each supporting up to 8 Card Readers. 25% spare shall be available in each controller.
e. Controllers shall the capability to support I/O Card of 128 monitored digital input points and 32 digital output points.
f. Any ACP, which uses a volatile memory, will be energized through UPS.
g. Detection circuits supported by the ACP shall be supervised.
h. The ACP shall have fast communication response time to achieve the security requirements as specified.
i. It shall have the ability to operate in local decision mode in case of any communication loss with the main ACP.
j. Hardware and Software:

1) The hardware and software of the ACP shall have at least the capability of saving and downloading databases, remote data analysis, allowing or prohibiting the access through physical aids, transferring data with other communication means and printing.
2) In local mode, the Controller shall also retain the access and alarm events (minimum 10,000 events), and shall download the data to the main Server upon restoration of communication.

k. The ACP shall be microprocessor based and shall include dynamic and static memories with enough capacity to cater for all the required databases. The system-controlled components shall be grouped in one enclosure with power supply; self power regulation, heat dissipation ventilators, self-protection against power failures, surges and the like.
l. It should be capable of controlling relay outputs (number to be clarified by the Manufacturer).

m. ACP shall have serial and parallel ports as well as Ethernet (TCP/IP). Communication with Card Readers should be achieved with twisted pair shielded cables and cable length limitation shall be at least 150 m.

n. Accessories shall include at least, but not limited to, diagnostic LED for status indication (ON, OFF, FAULT), data processing flashing LED and ports status LED (TRANSFER, DISABLED, FAULT).

o. The modular multitask units shall:

1) Constantly control the status of equipment.
2) Collect information.
3) Send data to workstations.
4) Work as independent processors.
5) Use a high level programming language, ensuring reliability, future extension, etc.
6) Capability and ease of maintenance.

p. Each unit shall contain:

1) Communication interfaces,
2) Universal digital input, digital output controls,
3) Universal analog input, analog output controls,
4) A plug-in communications module for maintenance,
5) A friendly language display,
6) Built-in time reminder functions to ensure that special maintenance requirements will be steadily annunciated,
7) Self-diagnostic system,
8) Voltage switching relays.

q. The Central Memory Unit shall perform the following functions:

1) Connection of the programming console (directly, or via the network),
2) Running of the application program,
3) ACP operating mode control,
4) Time stamp,
5) Control of 5 ms to 1 second programmable watchdog device,

r. The program memory is a non-volatile RAM type memory battery safe.

s. Each ACP shall include a main supply for its electronic components and an inside special one for low current, towards sensors or other processing systems required.

t. In case of network cut-off downwards the workstations, the ACP and programmable modules shall keep on the recorded data.

## X350 CARD READER FUNCTIONALITIES

1. Main Functionalities:

    a. Each Card Reader shall be intelligent and of the “Proximity” digital operation technology to be able to read the following standard without any hardware modifications:

        1) 13.56 MHz (ISO 14443 A/B and 15693).

    b. Each Card Reader shall communicate directly back to the access control panel.
    c. The Card Reader must operate over shielded cable using both Wiegand and RS-485 or IP Protocol without any additional power supplies.
    d. The Card Reader shall communicate to the access control panel in a supervised mode of communications. In the event of a reader malfunction, it shall be capable of being detected by the access control panel and an alarm must be generated at the workstations.
    e. Full error checking shall be provided within each reader prior to sending the information to the access control panel.
    f. The installation of Card Reader will be implemented to cope with handicapped persons requirements and standards.
    g. They shall have the capability of being programmed to activate a built-in multicolor LED. Light on the front face of the reader to indicate, at least:

        1) The normal operation of the reader,
        2) The acceptance of the badge,
        3) The refusal of the badge,

    h. Alarm shall be generated and reported to the supervision station in case of reader tampering.
    i. Reading the badge information without contact.
    j. The read distance of a badge shall be at least 5 cm.
    k. Any technical defaults from the reader shall be forwarded to the Access Control Panel.
    l. To inform the user, visual and sound information must be provided on the reader. It shall be possible to inhibit this feature.

## X355 CARD READERS SPECIFICATIONS

1. Characteristics:

    a. The minimal distance between two badge-readers shall be provided in order to prevent electromagnetic interference.
    b. Standard communication protocol required:

        1) Full duplex protocol such as IP, RS-485 or RS-422.

2) Simplex communication protocol such as Wiegand, Clock/Data or any equivalent open protocol.

c. Different sizes shall be available; the maximum size shall not exceed 150 x 150 mm.
d. Card Readers shall support proximity digital cards of dual technology compliant with ISO 14443 A or B Standard and ISO 15693 (with a reading range of at least 70 cm).
e. All readers shall be weather resistant, suitable for indoor or outdoor use and use tamper proof screws for installation.
f. Readers shall be rated for operation at a temperature range of -30 deg. C to +65 deg. C and a humidity range of 0% to 100% RH, non-condensing.
g. Card Readers shall comply with international Electro-Magnetic Interference, EMI, regulations and shall have fast reading and data transferring process and shall communicate with the system controller via shielded twisted pair cables.
h. A built-in tamper switch contact within the reader is required.
i. Card Readers shall have esthetical shape, be weatherproof and indoor type, tropical proof and tamper proof. Outdoor type readers shall be suitable for outdoor mounting, UV and salinity proof.
j. Card Readers shall have a built-in buzzer and LED for a better understanding of the user.

## X370 REX SWITCHES

1. REX Switches (Request-to-Exit): Momentary-contact back-lighted REX switches, with stainless-steel switch enclosures.

   a. Enclosures: Flush or surface mounting. REX shall be suitable for flush mounting in the switch enclosures.
   b. Enclosures shall additionally be suitable for installation in the following locations:

      1) Indoors, controlled environment,
      2) Indoors, un-controlled environment,
      3) Outdoors.

2. Power: REX switches shall be powered from their associated Controller, using dc control.

## X375 DOOR CONTACT

1. Door Position Contact: Magnetic type, flush mounted on the door to provide potential-free output for the controller.

## X380 DOOR HARDWARE INTERFACE

1. General:

    a. The Contractor shall provide suitable devices for each door type for Security and Access Control Systems.
    b. Coordinate with doors, frames, and hardware specified in other sections.
    c. Provide all equipments related to SACS such as, but not limited to, CR, ACP, lock, and other accessory parts necessary to complete the installation.
    d. Provide all necessary components to supply power to devices from building power distribution system.
    e. All the wiring and equipments surrounding the access shall be hidden and implemented in the most secured area or side. They shall also be integrated in the design as per architectural specifications.

2. Panic Exit Devices and Fire Exit Devices with Alarm: Operation of the exit device shall generate an alarm and annunciate a local alarm.

3. Exit Alarm: Operation of a monitored door shall generate an alarm.

4. Electric Door Strikes: Use end-of-line resistors to provide power line supervision. Signal switches shall transmit data to Controller to indicate when the bolt is not engaged and the strike mechanism is unlocked, and shall report a forced entry. Power and signal shall be from the Controller.

5. Electromagnetic Locks: End-of-line resistors shall provide power line supervision. Lock status sensing signal shall positively indicate door is secure. Power and signal shall be from the Controller.

## X390 SEQUENCE OF OPERATION

1. Sequence of Operation for Access with Card Reader:

    a. If the card is valid, the door’s magnetic lock is released, and the opposite Card Reader will be disabled for the operating time.
    b. If the door is not pushed/opened within a pre-defined time (X = 4 sec.), the door will be locked again and the cardholder will be considered outside.
    c. If the door is opened during the pre-defined time (X = 4 sec.):

        1) Door contact will give a signal to the SACS that the door is opened through the door contact,
        2) After a pre-set time (Y = 10 sec.), the door should be closed; if not an alarm will be initiated at the SACS “Door Open Too Long”, a local alarm will be raised in the buzzer, the correspondent CCTV camera monitoring the specific door (if any), will pop-up to the alarm CCTV monitor.

d. The Card Reader shall go to its initial stage after the door is closed.
e. Login to the system will be done only when the door is open.
f. Sequence for infracted door or operated without a valid card:

1) Instantaneous alarm signal activated at the SACS "Door Forced to Open" + local alarm + pop up of the CCTV camera (if any).
2) Instantaneous local buzzer alarm shall be activated.
3) Buzzer alarm shall only be deactivated with a valid card at the alarmed Card Reader or through the central supervision workstation.

2. Sequence of Operation for doors having a Card Reader on one side and REX on the other side:

a. Same as above, but when to exit the personnel needs to push the exit button to instantaneously open the door to exit.

3. Note: A Card Reader has to unlock the 2 wings of the door, if double leaves doors are controlled.

4. Doors with Panic Bar and Card Reader:

a. In case the Panic Bar is pushed:

1) For the first 3 seconds, an internal alarm in the Panic Bar will be activated (without sending any signal to the SACS) and door will be kept closed.
2) If the Panic Bar is kept pushed for more than 3 sec., the local system alarm sounder shall be activated.
3) The door lock will be released even if the Panic Bar has not been kept pushed for the next 15 sec. In this case, an alarm signal will be send to the SACS.
4) The local alarm will remain activated until a valid card will be attended at the "Alarmed Card Reader".

5. Fire Exit Doors – Monitored:

a. For the first 3 seconds, an internal alarm in the Panic Bar will be activated (without sending any signal to the SACS) and door will be kept closed,
b. After the 3 seconds, the door will open instantaneously,
c. The door contact will give a signal alarm to the system,

## X395 WIRE AND CABLE TECHNICAL FUNCTIONALITIES

1. The Contractor shall supply all cable and wire for the following equipment:

a. From door hardware to interface box,
b. From AC/DC converter to interface box,
c. From CR to ACP,

d. From ACP to network equipment (in the technical room),
e. From every workstation to the network equipment,
f. Interfaces with other system except when specified.

2. This includes power as well as communication cables.

3. Power cable shall be provided by the AC/DC converter with a 220 V AC UPS fused outlet in the technical room.

## X396 WIRE AND CABLE TECHNICAL SPECIFICATIONS

1. Installation: All wiring and cable shall be installed in metal raceways or within equipment. Conductors within equipment enclosures shall be carefully cabled and laced. Individual conductors shall be tagged with markers indicating the function, source, and destination of all cabling, wiring and terminals. All cables and wires shall be identified, utilizing heat-shrink, pre-printed, wire markers.

2. Number of Conductors: As recommended by system Manufacturer for functions indicated.

3. Checking and Tests: After installation, and before termination, all wiring and cabling shall be checked and tested to ensure there are no grounds, opens, or shorts on any conductors or shields. A V.O.M. shall be utilized to accomplish these tests and a reading of greater than 20 Mega ohms shall be required to successfully complete the test.

4. Inspection: Visually inspect wire and cable for faulty insulation prior to installation. Protect cable ends at all times with acceptable end caps except during actual termination. At no time shall any coaxial cable be subjected to a bend less than a 150 mm radius.

5. Protection:

   a. Protect wire and cable from kinks.
   b. Provide grommets and strain relief material where necessary, to avoid abrasion of wire and excess tension on wire and cable.

6. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.

7. Identification:

   a. Identify components, conductors, and cables according to Division 16 Section “Basic Electrical Materials and Methods”.
   b. Color-code conductors, and apply wire and cable marking tape to designate wires and cables so media are identified and in co-ordination with system wiring diagrams.

8. Raceway: All raceways shall be installed in accordance with Division 16 Section “Raceways and Boxes”. Use communications cable tray wherever possible for low voltage cabling. Exposed raceway below 2.4 meters and in dry locations shall be rigid steel conduit.

9. Twisted-Pair Cables:

    a. Cables used in this project shall exceed Category 6 - ISO 11801 - 25N780 performances.
    b. All cables shall have the following capacities:

        1) 4 twisted-pair (simplex),

    c. Twisted-pair cable shall have the following characteristics:

        1) Nominal Impedance: 100 Ohm +/- 5%, 10-250 MHz.
        2) Tinned copper AWG23 conductors.
        3) 100% overall aluminum foil screened.
        4) Low Smoke Zero Halogen (LSZH) outer sheath.
        5) Metric marking indication with type of cable, year, ref., number.
        6) Ripcord.
        7) Propagation Speed: 72% c.
        8) Propagation Unbalance: 10 ns/km.
        9) Weight: 70 kg/km.
        10) External Diameter: 8.5 mm.
        11) Installation Temperature: -5° C / +40° C.
        12) Storage/Transport Temperature: -15° C / +70° C.
        13) Operating Temperature: 0° C / +60° C.
        14) Complies with IEC 60754-1.
        15) Complies with IEC 60332-3C.

10. RJ45 Connectors/Jacks:

    a. The Contractor shall use RJ45 8pts connectors complying with Category 6 - ISO 11801.
    b. Connectors shall be connected with simple tool allowing simultaneous connection of 4-pairs cable and control of un-twist operation.
    c. Connectors shall be provided with faceplates for communication outlet in gang widths.
    d. Faceplate shall fit with spring shutter and label holder.
    e. Given their location and cable function, faceplates shall be as follows:

        1) Green and adapted to patch panel for vertical wiring connectors.
        2) Blue and adapted to patch panel for horizontal wiring connectors.
        3) White modular 45 x 45 for terminal wall or floor outlet.

11. RJ45 Patch Cords:

    a. The Contractor shall provide Category 6 patch-cords complying with section 265 of this Specification.

12. PE insulated, finely stranded tinned copper conductor, with copper braid screen and PVC over-sheaths.

13. Power supply and communication cables shall be provided for all equipment of the system: controllers, servers, workstations, and printers.

## 276:X4 INTERFACES

### X401 INTERFACE WITH SYSTEMS

1. When hardwired interface is not required, software interface between any systems shall be as open as possible using open software communication protocol.

2. The Security and Access Control System shall exchange information through the Ethernet LAN network.

### X420 INTERFACE WITH CCTV

1. SACS shall be interfaced to the CCTV system. The system shall be capable of popping up the CCTV camera image that is associated with the alarm point, where applicable, on the CCTV workstation.

### X440 INTERFACE WITH SCN

1. The system shall be interfaced with the Structured Cabling Network to allow the communication between SACS and all above interfaced systems throw the backbone.

2. Redundancy cabling shall be provided to ACP.

3. The SACS shall be part of a redundant VLAN within the Ethernet backbone network.

### X450 INTERFACE WITH UPS

1. All ACP’s and other critical components shall be powered by UPS.

2. Other equipment, such as, modems, workstations, screens, etc. shall also be powered by UPS.

3. A 220 V AC UPS power cable shall be implemented with a fused outlet by each access.

4. All power supply and network interfaces shall be protect against voltage surges due to lighting.

## X460 INTEGRATION OF SACS EQUIPMENT WITH OTHER TRADES

1. The SACS Contractor shall propose Shop Drawings, to be approved by the Engineer, for each typical case of integration, as to avoid mismatches.

2. The integration of the SACS hardware (equipment, cables and cable routing) within each type of door and doorframe shall be studied in such a way to be done in factory and delivered on site to be ready for installation.

3. Pre-fabricated and integrated conduits into doors and door frames shall be installed in such a way to allow easy and secure integration of cables and wires.

4. It is the duty of the Contractor to coordinate with door hardware as to avoid any technical mismatches.

5. The Contractor shall ensure the full coordination between the SACS constraints and other systems such as CCTV, or any other interfaced system.

6. All the SACS systems shall be studied, installed and tested in order to offer an easy maintenance and access.

7. The coordination due by the SACS Contractor shall cover both hardware and software. It shall also cover all aspects of Shop Drawing elaboration, manufacturing, construction, testing and commissioning, to achieve a comprehensive system in proper and efficient working order.

8. The final coordination on site with civil works, facades, architecture, HVAC, plumbing, electrical and any other construction aspect, remains the duty of the Contractor.

## X480 CABLE ROUTING AND CONDUITS COORDINATION

1. Conduits installed inside controlled doors and frames shall be installed directly by the hardware supplier. When transfer hinges are necessary, it shall be also installed by the hardware supplier.

2. Conduits shall be equipped with draw wires.

3. Cables necessary for power supply from the AC/DC converter up to each SACS component shall be delivered, installed, and tested by the SACS Contractor.

4. Equally, all data interconnections from each SACS component up to the common interface box shall be delivered, install, and tested by the Contractor.

5. The Contractor is also in charge for the provision and installation of all additional conduits as to ensure the continuity up to the local interface box and AC/DC converter.

X490 INTERFACE WITH COMMUNICATION NETWORK ACTIVE COMPONENTS

1. The SACS shall be interfaced with the data switching equipment to allow ACP, Server, workstations and other active equipments to communicate through the LAN.

X495 INTERFACE WITH ARCHITECTURAL DESIGN

1. The SACS shall be interfaced with the architectural design in order to implement:

   a. Interface box close to the controlled or monitored point,
   b. AC/DC converter close to the controlled or monitored point,
   c. All equipment related to the SACS such as CR, etc.

2. The choice of the location shall be coordinated and submitted to the Employer for approval.

3. The methodology related to the integration of conduits, interface boxes, and AC/DC converters, conduits and any SACS equipment within walls, floors, facades and ceilings should be closely coordinate with the architectural design. Therefore, it is the duty of the Contractor in charge of the SACS to ensure the proper coordination with this design and any other involved parties.

4. When no space is available above false ceiling for the installation of the necessary AD/DC converters and the interface panel, an appropriated space can be found either integrated into the floor or nearby an available wall. However such integration shall be made as to allow easy maintenance during operation.

276:X5 POWER SUPPLY

X510 THE CONTRACTOR SHALL BE RESPONSIBLE for coordination between the different systems and with the electrical works to ensure this power supply source and for a complete operational system. It shall not be allowed to provide a separate power supply panel board for each system’s equipment. Specifications of the feeders and of the corresponding panels shall be in accordance with the relevant sections of the electrical Specifications.

## X520 MAIN FEATURES OF AC/DC CONVERTER

1. The Contractor shall provide power supply and AC/DC converter for, but not limited to:

    a. Door hardware (e.g. magnetic lock, flashing light, panic bar, hold open magnet, etc.),
    b. All SACS equipment (ACP, workstations, etc.),
    c. Server,
    d. Others as deemed necessary.

2. Power supply shall use input power of UPS 220 V AC, 50 Hz and output 24 V DC. Output voltage shall be filtered and regulated.

3. Provide multiple output circuits on individual breakers.

4. Power supply shall be housed in a key locked enclosure.

5. 220 V power shall be provided adjacent to the controllers in technical rooms. It shall not be in junction boxes and Card Readers shall be self powered through the Access Control Panels.

## X530 POWER SUPPLY FOR DOORS

1. All SACS equipment shall be connected to common AC/DC converters. This equipment, part of the SACS, shall be energized in 220 V AC, connected to a no-break source, delivered by the power supply system only. Therefore there is no need for any other individual power supply.

2. Conduits installed inside controlled doors and frames shall be installed directly by the hardware supplier. This also concerns the transfer hinge when necessary. However, cables necessary for power supply from the AC/DC converter up to each SACS components shall be delivered install and tested by the SACS Contractor. Equally, all data interconnections from each SACS components up to the common interface box shall be delivered, install, and tested by the SACS Contractor. The SACS Contractor is also in charge for the provision and installation of all additional conduits as to ensure the continuity up to the local interface boxes and AC/DC converters.

FIELD AND INSTALLATION WORK

276:1 INSTALLATION

1101 GENERAL

1. Scope of Work:
   a. The scope of work shall include, but not be limited to, detailed engineering, fabrication and coordination thereof, supply and installation of all above equipment, operator training, hardware, software, wiring, cabling, labor, supervision, management control, testing, commissioning, maintenance and 24-month extended warranty for all supplied equipment.
   b. Installation shall be supervised and tested by a representative of the Manufacturer of the system equipment. The work shall be performed by skilled technicians under the direction of experienced engineers, all of whom shall be properly factory trained and qualified for this work.
   c. In addition to the above, the Contractor is also expected to supply the following:
      1) Coordination meeting with the Project authorities,
      2) Coordination with all others traders and systems interfering with the design, installation and testing of the SACS,
      3) Progress reports and progress reviews,
      4) Insurance for the transport of the equipment,
      5) Quality assurance setup and management,
      6) Document management,
      7) Configuration management for the duration of the Project,
      8) Off-the-shelf software updates for the duration of the warranty,
      9) User documentation and training, including textbooks,
      10) Worksite expenses (setup and removal of temporary offices, worksite vehicles, site offices computers, printers, desks, etc.),
      11) Archival.

2. Equipment installation on site is to be limited to the layout and fixation, and inter-wiring of various items of the ready-made equipment.

3. Acceptance of works is to be restricted to the equipment and installations complying with the approved submittal, approved Shop Drawings, and the agreement of the Engineer.

4. All installation works, carried out by the Contractor, shall be done under the direct supervision of qualified technicians who are trained and have the relevant experience.

5. Provide 20 mm, minimum, thick plywood backboard to support the Access Control Panels (ACP) and associated equipment mounted to the wall in each room. Coordinate location and size of backboard with the Engineer prior to installation.

## 1201 EQUIPMENT DATA

1. Submit complete technical data including Manufacturer's catalogues and specifications, system description including operational aspects, system features, and components.

## 1301 SHOP AND CONSTRUCTION DRAWINGS

1. Submit drawings for approval.

2. Constraints to be studied by the Contractor as part of its necessary Shop Drawing development include:

    a. The classification of SACS at controlled points does not take into account any materials or specific manufacturing. It refers only to functionalities and equipment to be installed on each side.
    b. When no space is available above false ceiling for the installation of the necessary AD/DC converter and the interface panel, an appropriated space can be found either integrated into the floor or nearby an available wall.
    c. The integration of the SACS hardware (equipment, cables and cable routing), for each case of door manufacturing, shall be studied in such a way to deliver on site a package ready for installation.
    d. It is the Contractor's duty to coordinate with door hardware as to avoid any technical mismatches.
    e. The Contractor shall ensure the full coordination between the SACS constraints and other systems such as Fire Alarm System and CCTV, or any other interfaced system.
    f. All the SACS systems shall be studied, installed and tested in order to offer an easy maintenance and access.
    g. All coordination, due by the Contractor, covers both hardware and software. It also covers all aspects of Shop Drawing elaboration, manufacturing, construction, testing and commissioning, to achieve comprehensive systems in proper and efficient working order.
    h. The final coordination on site with civil works, facades, architecture, HVAC, plumbing, electrical and any other construction aspect, remains the duty of the Contractor.

## 1401 DETAILED SYSTEM SCHEMATIC DIAGRAM

1. Exact routing of cables, giving type and size.

2. Exact location of for instance ACP, and workstation as well as technical rooms.

## 1451 TYPICAL INSTALLATION DETAILS OF THE SYSTEM COMPONENTS

1. After installation, the Employer shall be able to perform hardware configuration changes to redefine any new mapping and modifications as desired without the services of the installer or Manufacturer.

2. Source codes will be supplied by the installer or Manufacturer.

## 1501 COORDINATION WITH OTHER WORKS

1. The Contractor is to undertake the proper coordination between the works and installations of SACS and those of all other systems and interfaces that are listed above.

2. The layout Shop Drawings is to also reveal the measures taken therein, and every fixation principle, and is to be subject to the approval of the Engineer.

## 1551 LAYOUT OF EQUIPMENT

1. All equipment is to be laid out as per the approved Shop Drawings.

2. After the proper layout of all equipment is accomplished, all components are to be labeled, and marked according to an approved labeling designations and materials.

## 1601 INSTALLATION INSTRUCTIONS

1. Install equipment to comply with Manufacturer’s written instructions.

## 1651 WIRING METHOD

1. Install wiring in raceway except within consoles, desks, and counters.

2. Conceal cable and raceway except in unfinished spaces.

## 1701 SPLICES, TAPS, AND TERMINATIONS

1. Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes, terminal cabinets and equipment enclosures.

## 1751 IMPEDANCE AND SIGNAL LEVELS

1. Match input and output impedance and signal levels at signal interfaces. Provide matching networks where required.

1801 IDENTIFICATION OF CONDUCTORS AND CABLES

1. Color-code conductors and apply wire and cable marking tape to designate wires and cables to identify media in coordination with system wiring diagrams.

2. Wall-Mounting Outlets: Flush mounted.

3. Floor-Mounting Outlets: Conceal in floor and install cable nozzles through outlet covers. Secure outlet covers in place. Trim with carpet in carpeted areas.

1851 WEATHERPROOF EQUIPMENT

1. Install units that are mounted outdoors, in damp locations, or where exposed to weather consistent with weatherproof rating requirements as IP 65 at least.

1901 LINE MATCHING TRANSFORMER CONNECTIONS

1. Make initial connections using tap settings indicated on Drawings.

1951 SUPERVISION

1. Installation shall be supervised and tested by a representative of the Manufacturer of the system equipment.

2. The work shall be performed by skilled technicians under the direction of experienced engineers, all of whom shall be properly factory trained and qualified for this work.

276:2 WIRE AND CABLE

2101 PRINCIPLES

1. All wiring and cable shall be installed in metal raceways or within equipment.

2. Conductors within equipment enclosures shall be carefully wired and laced.

3. Individual conductors shall be tagged with markers indicating the function, source, and destination of all cabling, wiring and terminals.

4. All cables and wires shall be identified, utilizing heat-shrink, pre-printed, wire markers.

2201 NUMBER OF CONDUCTORS

1. As recommended by system Manufacturer for functions indicated.

2301 CHECK-IN AND TESTS

1. After installation, and before termination, all wiring and cabling shall be checked and tested to ensure there are no grounds, opens, or shorts on any conductors or shields.

2. A V.O.M. shall be utilized to accomplish these tests and a reading of greater than 20 Mega ohms shall be required to successfully complete the test.

2401 VISUAL INSPECTION

1. Visually inspect wire and cable for faulty insulation prior to installation.

2. Protect cable ends at all times with acceptable end caps except during actual termination.

2501 PROTECTION

1. Protect wire and cable from kinks.

2. Provide grommets and strain relief material where necessary, to avoid abrasion of wire and excess tension on wire and cable.

2601 SPLICES, TAPS, AND TERMINATIONS

1. Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

2701 RACEWAYS

1. Use communications cable tray wherever possible for low voltage cabling.

2. Exposed raceway below 2.4 meters and in dry locations shall be rigid steel conduit.

2801 CABLE TRAYS

1. No SACS containment including cable trays, trunking, ducts, etc. shall be loaded more than 60% of the available space. The Contractor is responsible to size the containment appropriately taking into account all systems and the type of cables to be used based on selected Manufacturer for each system.

2. In general, SACS containment route shall follow the electrical containment route with sufficient clearance. However, any other routes followed shall be to the approval of the Engineer.

## 276:3 GROUNDING

### 3101 PRECAUTION

1. Properly ground each piece of electronic equipment prior to applying power.

2. Properly ground all shielded wire shields to the appropriate earth ground at the hub end only, not at the remote or device end.

### 3201 PRINCIPLES

1. Ground system components and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

2. Clean earth for each technical room and applicable peripherals shall be provided.

## 276:4 FACTORY TESTS

### 4101 THE FACTORY ACCEPTANCE TESTS

1. They are tests to be carried out in the Contractor's premises before delivery, which shall demonstrate that the system (both hardware/software and the system after integration of various sub-systems including servers, workstations, sensors, etc.) meets the technical requirements as stipulated in this Specification.

2. The Factory Acceptance Tests shall be carried out in a hardware and software environment, which simulates the final configuration of the system.

3. Some of the functional or performance tests, which cannot be conducted in a simulated environment, due to their nature and complications, may subject to the Engineer's approval be combined with the On-Site Tests.

4. All travels and trips costs shall be provided by the Contractor for the Employer senior engineers and the Designer Engineer in charge to control.

4201 TEST PLANS

1. All tests are to be carried on according to detailed test procedures, which is submitted by the Contractor and approved by the Engineer.

2. The tests are to cover every aspect related to the specifications of the material and their operation including, but not limited to, visual inspections, measurements, and operation.

4301 EQUIPMENT TESTS

1. Equipment is to be tested for quality and operation at the factory, and test certificates and reports, certified by an official testing authority, are to be submitted to the Engineer before dispatch of equipment to site.

4401 OPERATIONAL TESTS

1. Operational functions available at the workstation level shall be demonstrated at factory based on a simulation.

276:5 ON-SITE TESTS AND INSPECTION

5101 ON-SITE ASSEMBLY VERIFICATION

1. The purpose of this phase is to check the assembly and the connection of the equipment without any power supply.

2. Any verification can give raise to a punch list item either because of an anomaly or a none-conformity.

3. The verifications are made sequentially for geographical area, each area giving raise to its own punch list.

4. The punch lists are collated for each module and the phase report is only released when all the stipulations on the punch lists are cleared.

5201 TEST PLANS

1. All tests are to be carried on according to a detailed test procedure, which is submitted by the Contractor and approved by the Engineer.

2. The tests are to cover every aspect related to the specifications of the material and their operation including, but not limited to, visual inspections, measurements, and operation.

## 5301 ON-SITE CABLE TESTS

1. Cables are to be tested to ensure that no damage have occurred to them during transportation to site and/or during the course of pulling-in and laying.

## 5401 INSPECTION

1. Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.

## 5501 PRE-TESTING

1. Align and adjust system and perform pre-testing of all components, wiring and functions to verify compliance with specified requirements.

2. Correct all deficiencies by replacing malfunctioning or damaged items with new items.

## 5601 MANUFACTURER'S FIELD SERVICES

1. Engage a factory-authorized service representative to inspect field-assembled components and equipment installations and perform system pre-testing, testing, adjustment and programming.

2. Report results in writing.

## 5701 PROCEDURE

1. Notify the Engineer not less than 30 days in advance, of proposed schedule, procedures and tests to be used in operational testing.

2. Conduct operational tests only with Engineer present.

## 5801 REPORT

1. Prepare a written report of observations, inspections, tests and results, including:

    a. A complete listing of every device and circuit.
    b. Date of each test and re-test, and by whom.
    c. Results of each test and, if failure occurred, corrective action taken prior to re-test.

5851 CERTIFICATION

1. The contractor shall certify that all devices, circuits and total system finally tested successfully.

5901 OPERATIONAL TESTS

1. Schedule tests after pre-testing has been successfully completed.

2. Perform operational system tests to verify compliance with Specifications.

3. Test all modes of system operation including:

   a. Functional operation of each field mounted device.
   b. Functional operation of each control circuit.
   c. Supervision functions of each initiating, indicating, monitoring, and control circuit.

4. Integrated Tests with Other Contractors: The test procedures shall reflect the sequence of tests to be performed.

5. Re-testing: Correct deficiencies and re-test until total system meets requirements of the Specifications and complies with applicable standards. Prepare written records of tests.

6. Schedule testing with at least seven days advance notice.

5951 EXPERIMENTAL PERIOD

1. After the on-site tests are satisfactorily completed in accordance with the technical specifications and approved procedures and before final acceptance which is leading to Provisional Taking Over; the Contractor is to assume a three month experimental period during which the system performance will be fully demonstrated under actual operation conditions.

2. This demonstration is to confirm, to the satisfaction of the Engineer, that the system is free of remarks and is ready for provisional taking over.

276:6 TRAINING

6101 TRAINERS

1. Engage a factory-authorized service representative to explain programming and operation of system and to train the Employer’s maintenance personnel on procedures and schedules for maintaining, programming, operating, and adjusting, troubleshooting, and servicing system.

## 6201 TRAINING PROGRAM

1. Scope: Training shall be in sufficient scope to ensure that all trainees who complete the program will be certified as capable to operate and/or maintain the equipment, systems, and facilities furnished and installed under this Contract, and to ensure a smooth transition between construction and operations activities.

2. Language: Operators/Technical training shall be conducted in English and Arabic.

3. Training Aids:

    a. Training aids shall include approved operational an maintenance (O & M) manual(s) prepared by the Contractor as part of this Contract; training manuals including course outline, basic text of instructions modules, and trainee workbook; films; slides; video tape(s); charts; models; hand-outs; catalogues; samples and other visual and written aids to complement instruction.
    b. In addition, spare parts and other special hardware shall be provided to support “hand-on” familiarization with the equipment or systems.
    c. Upon completion of the training program, all training aids, test equipment, and similar items provided by the Contractor for this training program shall become the property of the Employer.

4. Training Manuals:

    a. Training manuals in English and Arabic shall be provided for each training course covering both the classroom and on-the-job training phases..
    b. The organization of the manuals shall follow the same sequence as the course’s scheduled presentation of material, providing such additional background and supplementary information, as a trainee may need to understand the O&M manuals.
    c. There should be at least the following training manuals:

        1) SACS supervisor training.
        2) Electronics maintenance training.
        3) ACP/CR/network/workstation terminal maintenance training.

5. Training Execution:

    a. Scope: Training shall be performed in accordance with an approved training program. All training aids shall be available and approved prior to start of training.

    b. Contents:

        1) Training course can be broken down into modules either classroom lecture or “On-the-job” training.

2) In case of lecture it is the Contractor's responsibility to provide the classroom for the duration of the course.
3) No lecture module should exceed 2 hours time.
4) "On-the-job" training can be scheduled for entire 8-hour shift.
5) At least one module for each maintenance staff should cover the SACS system and its interfaces.
6) Handouts must support each module; the collation of the handouts forms the training manual.
7) Laboratory equipment, spare parts and mock-up models may be used for theoretical orientation.
8) However, practical "hands-on" familiarization shall be provided on equipment that is either installed and operable or ready to be installed and capable of being operated. System spares of special hardware items may be used to support "hands-on" familiarization as long as said spares are returned to inventory in satisfactory condition in accordance with approved procedures.

c. Proficiency: At designated intervals each trainee's proficiency level shall be determined by written, oral and practical performance tests.

## 276:7 GUIDELINES FOR DOCUMENTATION TRANSMITTAL

### 7101 CONTENT OF THE TRANSMITTALS

1. The Contractor shall prepare detail drawings, design calculations, technical data sheets and samples and submit the same for review by the Engineer. The Contractor shall submit the following key elements to the Engineer for review:

   a. Detailed layout showing the marking and/or the detection equipment as required.
   b. Manufacturers' catalogue.
   c. Provide all relevant testing certificates.
   d. Inventory label for each item supplied under this Contract. Labels shall be submitted for review by the Engineer and shall be attached to each individual item for easy reference.

2. Following documents are to be submitted to the owner prior to handing over:

   a. As-built drawings for the relevant areas.
   b. Complete inventory list.
   c. Three sets of Operation and Maintenance Manuals are to be provided. Such manuals shall include a full technical description with block and schematic diagrams to allow the Employer's staff to maintain the machines.

# 29 OTHER WORK IN CONNECTION WITH ELECTRICAL WORK

## 291 BUILDER'S WORK

### 291:A GENERAL

A101 BUILDER'S WORK GENERALLY: materials and workmanship, unless otherwise specified, are to be in accordance with the relevant requirements of the Specification for Structural and Architectural work.

A151 DESCRIPTION OF WORK: cable and duct trenches, equipment foundations, bases and supports, ducts and duct banks, manholes, handholes and earth pits, chases, holes and the like, sleeves, bolts, brackets and fixings including grouting.

A201 COORDINATION: confirm locations and dimensions of all builder's work required for electrical work. Submit shop and construction drawings or other data to the Engineer for checking before proceeding with the work.

A251 ROUTES FOR SERVICES BELOW GROUND: agree precise locations with the Engineer, set out clearly and accurately and locate with temporary marker posts.

### PRODUCTS AND MATERIALS

### 291:H COMPONENTS

H105 POLYVINYL CHLORIDE (PVC) DUCTS for outdoor power and lighting cable installations are to be non-sparking type, suitable for direct burial in ground, minimum tensile strength 500 kg/cm2, impact strength 5 kg/cm2, supplied in standard 6 m lengths, with one end of each length tapered. Ducts are to be nominal size shown on the Drawings, with minimum wall thickness 3.2 mm for 100 mm ducts and 4.7 mm for 150 mm ducts.

H155 DUCT SUPPORTS: pre-formed, non-metallic of approved type. Supports containing metal are to have the metal non-continuous and not forming a magnetic loop in any manner.

H205 COVERS FOR TRENCHES in electrical rooms and the like, unless otherwise specified or shown on the Drawings, are to be flanged chequered steel plates with angle or channel- section frames, suitably reinforced to support anticipated loads, and finished with zinc chromate primer and two coats grey enamel.

H305 COVERS FOR MANHOLES AND HANDHOLES: to BS EN 124, chequered cast iron or cast steel, recessed type, and of suitable duty for the particular application.

H405 BRACKETS, SUPPORTS, RAILS AND TRACKS for supporting electrical installations are to be galvanized steel, fixed with expansion bolts of approved size and material. Plastic inserts and lead anchors are not acceptable unless approved for specific light duty installations.

## 291:X COMPOSITE CONSTRUCTION

X105 EQUIPMENT FOUNDATIONS AND BASES: reinforced concrete, as approved by the Engineer after submission of design calculations. Dimensions, levels and surface finishes are to be suitable for equipment installed, as shown on the Drawings or in accordance with approved shop and construction drawings.

X205 CONCRETE ENVELOPE FOR DUCT BANKS for power distribution systems and outdoor lighting cable installations crossing water, gas and sewage mains, under roadways and where required or shown on the Drawings, is to be reinforced concrete according to specifications. Calculations to be submitted for the engineer’s approval. Length of concrete envelope is to extend at least 300 mm beyond each side of crossing etc.

X305 CABLE MANHOLES AND HANDHOLES: reinforced concrete according to concrete specifications, with approved waterproof membrane on external surfaces, and with cable supports where necessary, pull-eyes, and drain pit and drain pipe as required. Dimensions and reinforcement are to be as shown on the Drawings or in accordance with approved standard details shown on shop and construction drawings.

## WORKMANSHIP

## 291:1 GENERALLY

1101 CABLE TRENCHES: width is to be as small as practicable with sides vertical. Remove mud, rock projections, boulders and hard spots from trench bottom and trim level. Inform the Engineer in advance to give him reasonable opportunity to inspect trench for each section of the work.

1201 DIRECTLY BURIED PVC CABLE DUCTS:

lay and join ducts to required line and level on sand bed, cover with sand and backfill trench to ground level with excavated soil, free from stones and other debris, well compacted in layers not exceeding 300 mm thick

lay approved concrete tiles to fully cover cable duct, extending minimum 50 mm beyond sides of duct and placed 300 mm below ground level

provide warning tape or galvanized steel mesh along duct runs at a depth 200 mm below ground level.

1251 UNDERGROUND CABLE DUCT ASSEMBLIES:

form duct assembly to required line and level, using duct supports spaced to prevent sagging of ducts and breaking of couplings and watertight seals, and secured with cords (not tie wires) where necessary

provide 1% slope to duct banks for draining to exterior manhole, handhole or other location as instructed

join ducts using waterproof cement, to manufacturer's recommendations, to give waterproof and sandproof joint with at least 80 mm overlap

provide 3 mm galvanized steel wire inside empty ducts, for future pulling of cables, extending 1 m beyond duct banks at both ends and securely fixed to wooden bungs sealing the duct.

1251 ENDS OF DUCTS: ducts ending in cable manholes or handholes are to be neatly cut and reamed and set behind chamfered precast concrete duct end blocks or terminated with appropriate bell-mouth bushing set in concrete wall. Ducts not ending in cable manholes or handholes are to be properly capped.

1261 SEALING ENDS OF DUCTS: conduits and ducts, active or spare, at entry into building or manhole, are to be completely sealed with approved plastic moulds or wooden bungs to prevent entry of rodents, gas and vapour.

1301 SLEEVES OR DUCTS IN EQUIPMENT FOUNDATIONS are to be provided, whether shown on the Drawings or not, and in accordance with approved shop and construction drawings or as instructed by the Engineer. Obtain approval of sleeve or duct installation prior to concreting.

1401 SUPPORT FRAMES FOR SWITCHGEAR located over cable trenches, where shown on the Drawings or required by equipment design, are to be installed prior to concreting.

1451 DRILLING FOR ANCHOR BOLTS is to be carried out using appropriate electric drills and in approved positions.

1501 HOLES AND CHASES IN IN SITU CONCRETE are to be cast in. Do not cut hardened concrete or drill holes larger than 10 mm diameter without prior approval.

1551 HOLES AND CHASES IN PRECAST CONCRETE: do not cut or drill precast concrete without prior approval.

1601 HOLES IN STRUCTURAL STEELWORK: do not cut or drill structural steelwork without prior approval.

1701 HOLES AND CHASES IN MASONRY must not exceed:

| | | |
|---|---|---|
| size of holes | : | 300 mm square |
| depth of vertical chases | : | 1/3 wall thickness or, in cavity walls, 1/3 leaf thickness |
| depth of horizontal chases | : | 1/6 wall or leaf thickness. |

1751 CUTTING MASONRY:

ensure mortar is fully set before commencing

cut carefully and neatly, avoiding spalling, cracking or other damage to surrounding structure

keep holes to smallest practicable size and do not exceed specified dimensions

cut chases in straight lines and horizontally and vertically only; do not set back to back; offset by a distance not less than wall thickness.

1761 PREFORMED HOLES IN MASONRY: submit proposals for bridging over holes for ducts etc. which exceed 460 mm width.

291:2 INSPECTION AND CLEANING

2101 INSPECTION OF DUCT SYSTEMS: directly buried ducts and underground duct assemblies are to be inspected in the presence of the Engineer, before backfilling or concreting. Steel mandrel or other approved device, diameter equal to 90% of inside diameter of duct and 500 mm long, is to be pulled through entire run of duct and is to pass through without getting stuck. Ducts which do not allow mandrel to be pulled through are to be repaired or replaced to the satisfaction of the Engineer.

2201 CLEAN DUCTS with stiff bristle brush pulled through each duct prior to pulling in cables.

# 302 TESTS ON SITE, RECORDS, TRAINING AND MAINTENANCE

## 302:1 TESTS ON SITE

1101 GENERALLY: carry out inspection and acceptance tests on site on each complete system before final placement into service, in accordance with the Regulations and Standards, as described in the Specification and required by the Engineer.

1151 TEST SCHEDULES AND PROCEDURES are to be submitted for approval and are to include details of testing equipment to be provided.

1201 WITNESSING: inspection and acceptance tests are to be carried out in the presence of the Engineer and, when required, by an authorized representative of the Local Power Authority.

1301 VISUAL INSPECTION: visually check proper installation, connections and nameplate data before testing.

1401 INSULATION AND CONTINUITY TESTS: test all control, signal and power circuits and motor/drive, for continuity and insulation resistance and record all readings.

1601 OPERATIONAL TESTS: carry out operational tests on complete systems to verify proper performance in compliance with the Specification. Tests are to be carried out under normal operating conditions for not less than 3 days, and as required by the Engineer.

1701 SPECIFIC TESTS: carry out specific tests required by the Specification and any other tests required by the Engineer to verify compliance of the installations with the Specification.

## 302:2 RECORDS

2101 GENERALLY: not later than the date of substantial completion, provide the Engineer with four copies of all approved as-installed drawings, test records, manufacturers' guarantees and warranties, operating and maintenance manuals and other records required by the Specification.

2151 PRESENTATION OF RECORDS is to be in A4 size plastic covered, loose-leaf ring binders or other approved binders with hard covers, each indexed, divided and appropriately cover titled. Drawings larger than A4 size are to be folded in the binders so that they may be unfolded without being detached.

2201 AS-INSTALLED DRAWINGS are to contain the complete assembled information included on the construction drawings, prepared in the same manner, and up-dated to indicate the systems, labelling, referencing, mounting methods, routing etc. as installed. Submit complete drawings for approval. Provide the Engineer with one set of transparencies in addition to the four copies required.

2301 TEST RECORDS are to include test certificates of type tests, work tests, site tests, commissioning and performance tests and all other tests on equipment and installations described in the Specification and required by the Engineer. Information is to include test procedures and results, conditions under which tests were carried out including set points, temperatures and the like, dates, location and attendance by authorized representatives etc.

2401 OPERATING AND MAINTENANCE MANUALS are to contain the following:

technical description of control system and each item of equipment installed, written to ensure that the Employer's staff fully understand the provisions and operation

diagrammatic drawings of each system indicating principle components and items of equipment

schedules of equipment installed giving manufacturer, catalogue list numbers, model and serial number, rating and characteristics; each item is to have a unique code and number, cross-referenced to the diagrammatic drawings and layout drawings

name, address, telephone, telex and fax numbers of the manufacturer of every item of equipment

name, address, telephone, telex and fax numbers of equipment agents/representatives for emergency services and procedures

manufacturer's service manual for each major item of equipment, including detailed drawings, illustrations, circuit details, operating and maintenance instructions, modes of operation, control provisions, sequences and interlocks and preventative maintenance programme

manufacturers' lists of recommended spare parts for items subject to wear and deterioration, giving expected running period and indicating specifically those items which may involve extended deliveries.

2402 OPERATING AND MAINTENANCE MANNUALS: prepare two temporary copies with provisional record drawings and preliminary performance data and make available at time of testing and commencement of commissioning to enable the Employer's staff to familiarize themselves with the installations. Temporary copies are to be in the same format as the final manuals with temporary insertions for items which cannot be finalized until the installations are commissioned and performance tested.

## 302:3 TRAINING

3101 OPERATION AND MAINTENANCE TRAINING: before the date of substantial completion, explain and demonstrate to the Employer's maintenance staff the function and operation of the controls and other components as necessary.

## 302:4 MAINTENANCE

4101 MAINTENANCE CONTRACTS: submit supplementary proposals for annual maintenance contracts. The proposals are to:

include for maintaining the installations in efficient working order including routine and emergency service checks, adjustments, lubrication and the supply and replacement of damaged parts etc.

set out the terms of the offer, the work to be carried out, the guarantees of performance and the price of the work or part thereof for the first twelve months after substantial completion.

The proposals will not be considered as part of the Tender.

# 4 PLUMBING

## 41 PLUMBING - GENERAL

### 411 GENERAL REQUIREMENTS

#### 411:1 DRAWINGS, INSTRUCTIONS AND SAMPLES

1051 EQUIPMENT AND MATERIALS LISTS: within 30 days after the Commencement Date, submit lists of equipment and materials, with names of proposed manufacturers and drawings of interrelated items. All submissions are to show submission dates.

1101 SHOP AND INSTALLATION DRAWINGS: at least two months prior to commencement of any installation, submit for approval detailed shop and installation drawings showing to-scale dimensions of equipment, pipes etc. in plan and elevation with clearances and relation of same to space assigned.

1102 SHOP AND INSTALLATION DRAWINGS of equipment and material are to include manufacturer's detailed drawings, cuts of catalogues and descriptive literature showing type, performance characteristics, construction, component parts, dimensions, arrangement, operating clearances, capacity, electrical characteristics, power requirements, motor, drive and testing information.

1103 SHOP AND INSTALLATION DRAWINGS: submit manufacturer's certified drawings, templates and installation instructions for all equipment showing operating weights, weight distribution, location of vibration isolation mounts, size and location of anchor bolts, drainage and other openings and other pertinent data to assist in design of bases and supports.

1104 SHOP AND INSTALLATION DRAWINGS: mark clearly in ink catalogues, pamphlets and manufacturer's drawings for proper identification of item proposed and indicate, with reasons, deviations from the Specification and the Drawings.

1105 SHOP AND INSTALLATION DRAWINGS: submit for approval in letter form, materials not covered by drawings e.g. pipes, fittings and incidentals giving ratings and names of manufacturers.

1106 SHOP AND INSTALLATION DRAWINGS: no equipment or materials are to be purchased or delivered to Site until drawings etc. have been approved.

1111 FURTHER DRAWINGS: during the progress of the work, submit shop-drawings, to 1/20 or 1/10 scale, as required by the Engineer and as specified elsewhere.

1151 ENGINEER'S DRAWINGS are generally diagrammatic and are not to be scaled. Measurements are to be made from established bench marks.

1152 ENGINEERS DRAWINGS: check all architectural, structural and electrical drawings in laying out work to verify adequacy of space in which work is to be installed. Notify the Engineer where space appears inadequate.

1161 SUBSTITUTION OF EQUIPMENT AND MATERIALS: reference to equipment or material by name, make or catalogue number and lists of approved manufacturers are to be interpreted as establishing standard of quality and performance and are not intended to eliminate equivalent products of other manufacturers.

1201 MINOR CHANGES AND MODIFICATIONS may be made in layout to prevent conflict with work of other trades or for proper execution of the work.

1211 CO-OPERATE with other trades to permit their work to be installed satisfactorily and with minimum interference or delay.

1221 CO-ORDINATE space requirements in shafts, chases, double partitions and hung ceilings with other trades.

1231 FURNISH to other trades templates, patterns, setting out plans and shop details necessary for proper installation and co-ordination of adjacent work.

1241 PROTECTION: close open ends of work with temporary covers or plugs during storage and construction.

1251 PAINT FINISH: equipment to have factory applied enamel paint finish.

1301 INSTRUCTION MANUALS: provide six copies in bound booklet form containing the following information:

brief description of each system and piece of equipment with basic operating features

descriptive literature of equipment and components with manufacturer's name, model number, capacity rating and operating characteristics

service manual prepared by manufacturer for every major piece of equipment giving operating and maintenance instructions, starting and shut-down instructions, lubrication instructions and list of possible breakdown and repairs

manufacturer's list of general spare parts for every piece of equipment, with unit prices

manufacturer's list of recommended spare parts for one year of operation for every piece of equipment, with unit prices

detailed and simplified one line, colour coded flow diagram of each system with tag number, location and function of each valve and instrument

detailed and simplified colour coded as-installed wiring diagrams of motor controllers and automatic controls with tag number, location of each instrument and electrical device with description of sequence of operation and interlocks.

1302 INSTRUCTION MANUALS: submit in draft form for review and approval prior to final issue and at least four weeks in advance of completion date of the system.

1351 RECORD DRAWINGS: submit an approved complete set of as- built drawings and electrical wiring diagrams in tracing or other reproducible form.

1401 SAMPLES: submit samples of proposed materials and workmanship for approval.

## 411:2 ACCESS DOORS AND FRAMES

2101 ACCESS: install work to be readily accessible for operation, maintenance and repair. Approved deviations from the Drawings may be made to accomplish this.

2111 PURPOSE: ensure that access doors and frames are provided for easy access to concealed equipment, controls, valves, traps, vents, drains, clean-outs, and other devices requiring periodic operation, inspection and maintenance.

2121 DETAILS: access doors and frames are to be provided by others. Provide details, dimensions and locations of access doors required and submit for approval in sufficient time to enable doors to be installed during normal course of work.

2131 IDENTIFICATION: access doors are to be identified to indicate location of concealed work. Method and schedule for identification of access doors is to be approved.

## 411:3 LABELS, TAGS AND CHARTS

3001 NAMEPLATES: each piece of equipment is to have a conspicuous certified nameplate permanently attached at factory, printed or stamped clearly with name and address of manufacturer, equipment model number, serial number, date of manufacture, electrical characteristics, performance rating or duty, pressure, temperature or other limitations and other pertinent data.

3051 LABEL AND IDENTIFY equipment, instruments, controls, electrical devices, valves etc. as to duty, service or function. Label controls and electrical devices to indicate clearly what they control.

3061 LABELS: attach to equipment etc. or to adjacent permanent surfaces in an approved permanent manner.

3101 TAG controls and instruments that cannot be easily identified with Bakelite labels.

3102 TAG valves and controls except equipment shut-off valves located at equipment.

3151 LABELS AND TAGS: submit for approval a schedule of equipment and devices to be labelled and tagged, with suggested nomenclature

3201 CHARTS are to be prepared of schematic flow diagrams of each piping system with location and function of each valve and with type and size of each essential feature of the system.

3202 CHARTS: prepare schedules for equipment lubrication and maintenance and essential operating instructions.

3203 CHARTS: submit for approval.

3204 CHARTS: mount on wooden plaques or 6 mm Masonite boards, cover with heat bonded clear plastic laminate or frame under glass and permanently fix with four brass screws at approved locations.

## 411:4 TRAINING

4051 INSTRUCT AND TRAIN Employer's designated personnel in the operation and maintenance of every part, device and piece of equipment in the systems, with emphasis on proper start-up and shut-down procedures, preventive maintenance and lubrication procedures with recommended lubricants, overhaul and maintenance methods, adjustment and calibration of instruments and controls, use of special tools and safe practices.

4061 EXPENSES: the Employer will bear all expenses his personnel allocated for training.

## 411:5 INITIAL OPERATION OF SYSTEMS

5051 AFTER INSTALLATION IS COMPLETE, operate systems for time required to complete tests specified under CLEANING, TESTING, BALANCING AND ADJUSTING, to demonstrate performance in accordance with design requirements and to provide instruction and training to the Employer's designated personnel.

5061 COMMENCEMENT OF DEFECTS LIABILITY PERIOD: to start on the date of substantial completion stated in the Taking-Over Certificate issued by the Engineer, in respect of each system..

## 411:6 NOISE AND VIBRATION

6051 EQUIPMENT is to operate under all conditions of load without objectionable sound or vibration.

6101 NOISE AND VIBRATION noticeable outside a room in which moving equipment is installed, or annoyingly noticeable inside the room, will be considered objectionable.

6151 NOISE LEVEL resulting from equipment and heard in the same building or nearby buildings is not to exceed 40 decibels as measured with a standard sound level meter on the 'A' scale.

6201 CORRECTION: conditions considered objectionable are to be corrected by approved means and as directed.

6251 VIBRATION CONTROL is to be by approved vibration isolators applied and installed in accordance with manufacturer's instructions.

## 411:7 DEFECTS LIABILITY PERIOD

7001 GUARANTEE during the Defects Liability Period is to cover perfect mechanical operation of systems, acceptable noise and vibration levels and reasonable consumption of power, fuel and water.

7051 DEFECTS: if during the Defects Liability Period any equipment or material proves defective or any part of system fails to function properly, equipment is to be replaced and defects and malfunctions corrected as directed by the Engineer.

7101 EXTENSION OF DEFECTS LIABILITY PERIOD: if during the Defects Liability Period any piece of equipment is replaced or rebuilt, the Defects Liability Period is to be extended for this equipment for a new period equal to the original period.

7151 MAINTENANCE AND OPERATION: provide during the Defects Liability Period all necessary skills and labour to assure proper operation and to provide regular and preventive maintenance required for equipment and controls, on a continuous 24 hour basis.

7152 MAINTENANCE AND OPERATION: act promptly to correct problems arising in operation of equipment or system.

7153 MAINTENANCE AND OPERATION: provide the Employer with monthly inspection certificates of equipment, record findings on a check list and certify that each piece of equipment has been examined, is operating as intended and has been properly maintained as recommended by manufacturer.

7154 MAINTENANCE AND OPERATION: check all controls monthly to ascertain that they function as designed.

7201 SPARE PARTS for normal wear and tear are to be provided by the Employer.

## 411:9 STANDARDS

9051 STANDARDS: abbreviations are to mean the following:

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|---|---|
| AGA | American Gas Association |
| ANSI | American National Standards Institute |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| AWWA | American Water Works Association |
| BS | British Standards Institution |
| DIN | Deutsches Institut fur Normalisierung |
| FM | Factory Mutual System |
| ISO | International Standardization Organization |
| NBS | National Bureau of Standards |
| NFPA | National Fire Protection Association |
| SAE | Society of Automotive Engineers |
| UL | Underwriters' Laboratories Inc. |

# 412 PIPES AND FITTINGS

## PRODUCTS

### 412:H PIPES AND FITTINGS

### 412:H1 FERROUS PIPES AND FITTINGS

H110 DUCTILE IRON PIPES AND FITTINGS: to BS EN 545 for water pipelines; BS EN 598 for sewerage pipelines; and BS EN 969 for gas pipelines. Pipes to be centrifugally cast with PN 16 flanges integrally cast. Fittings to be double flanged of same standard and manufacture as pipe. Pipe and fittings to be coated at factory with coal tar base solution to BS 4l64.

H130 FITTINGS FOR BLACK STEEL AND GALVANIZED PIPES: fittings for black steel pipes 50 mm diameter and under and for all galvanized pipes to be screwed malleable iron, 1030 kPa steam working pressure rating, banded type.

H131 FITTINGS FOR BLACK STEEL PIPES over 50 mm diameter to be steel seamless butt-welding with 37 degrees bevelled ends, of same schedule, thickness and rating as pipe of corresponding size.

H132 FITTINGS FOR BLACK STEEL PIPES where backwelding is required to be screwed forged steel.

H140 FLANGES to be of same pressure rating, facing, drilling and thickness as mating flanges on valves, accessories and equipment.

H141 FLANGES ON BLACK STEEL PIPES to be black forged steel slip-on or weld neck type.

H142 FLANGES ON GALVANIZED STEEL PIPES to be galvanized steel threaded type.

H144 FLANGES ON DUCTILE IRON PIPES AND FITTINGS to have serrated finish.

H145 GASKETS for flanged joints in ductile iron pipes to be high grade natural rubber to BS EN 681-1.

H146 GASKETS for flat face flanges on steel pipes to be full face ring type with punched holes.

H150 RING GASKETS: to ASME B16.21, suitable for chemical and thermal conditions of piping system contents; non-metallic, flat, asbestos-free, 3.2 mm thick unless otherwise specified.

H160 BOLTS AND NUTS: black steel to BS 4190 of length to allow nuts to utilize full length of thread.

H165 THREAD SEALANT: Teflon tape or approved special joint compound.

412:H2 NON-FERROUS PIPES AND FITTINGS

H215 LEAD PIPE to be hydraulic press extruded, to BS 1085.

H220 CAULKING FERRULES for connecting lead pipe to cast iron soil pipe to be red brass 115 mm long.

H225 SOLDERING BUSHINGS for connecting lead pipe to steel pipe to be screwed brass.

H230 NON PRESSURE PVC PIPE: to BS 5255 for 32 mm, 40 mm and 50 mm pipes; to BS 4515 for 82 mm, 110 mm and 160 mm pipes installed above ground; to BS 4660 for 110 mm and 160 mm pipes installed below ground; and to BS 3506 for 200 mm pipes and above.

H235 NON PRESSURE PVC FITTINGS: couplers or mechanical joints with rubber sealing rings.

H240 PRESSURE PVC PIPE: to BS EN 1452-1, BS EN 1452-2, BS EN 1452-3, BS EN 1452-4 and BS EN 1452-5.

H245 PRESSURE PVC FITTINGS: integral parallel sockets with solvent welded joints for pipes up to 65 mm, and couplers with rubber sealing rings for pipes 82 mm and larger.

H250 SEALING RINGS ON PVC PIPES to provide for expansion and contraction to be rubber to BS EN 681-1.

H270 POLYPROPYLENE PIPES: to DIN 8077 and DIN 8078, PN 25.
H275 POLYPROPYLENE FITTINGS: to DIN 16962 all Parts. Welded type generally, threaded type for connection to threaded valves.

H280 POLYETHYLENE PIPES AND FITTINGS: high density type to DIN 19535-1 and DIN 19535-2; of suitable grade for above and below ground applications and resistant to corrosion, hot water and chemicals. Fittings are to be of the electro-weld sleeve coupling type, or as recommended by manufacturer for particular application and installation:

Man: Geberit
Ref: HDPE

or approved equal.

412:H5 PIPE ACCESSORIES

H505 PIPE ACCESSORIES to be same size as pipe run.

H510 PIPE UNIONS on threaded pipes 50 mm diameter and under to have female threaded ends and ground metal to metal seats. Unions to be of same manufacture, pressure class and material as other pipe fittings.

H515 ELBOWS to be long radius type.

H520 DIELECTRIC INSULATED UNIONS AND FLANGES to be suitable for temperature, pressure and all other operating conditions of service on which used. Dielectric insulated flanges to have insulating gaskets between flanges and Teflon sleeves and washers between bolts and nuts and the flanges.

H521 DIELECTRIC INSULATED UNIONS AND FLANGES: obtain from one of the following:

Capitol Mfg. Co. (U.S.A.)
Dresser (U.S.A.)

or approved equal.

H530 FLEXIBLE CONNECTIONS: seamless bronze tubing with annular corrugations covered with high tensile bronze braid suitable for 1030 kPa cold water working pressure.

H531 FLEXIBLE CONNECTIONS to have screwed ends for pipes 50 mm diameter and under and flanged ends for pipes over 50 mm diameter.

H532 FLEXIBLE CONNECTIONS: obtain from one of the following:

| | |
|---|---|
| Senior Flexonics | (U.S.A.) |
| Mason Industries Inc. | (U.S.A.) |
| Viking Johnson Ltd. | (U.K.) |

or approved equal.

H535 EXPANSION JOINTS: stainless steel, packless bellows type, suitable for 130 kPa steam working pressure and 1720 kPa cold water working pressure.

H536 EXPANSION JOINTS to have screwed ends for pipes 50 mm diameter and under and flanged ends for pipes over 50 mm diameter.

H537 EXPANSION JOINTS: obtain from one of the following:

| | |
|---|---|
| Senior Flexonics | (U.S.A.) |
| IWK | (Germany) |
| Keflex, Inc. | (U.S.A.) |

or approved equal.

H540 HANGERS AND SUPPORTS: submit drawings for approval.

H541 HANGERS AND SUPPORTS are to allow adjustment of slope of piping and removal without dismantling pipes.

H543 HANGERS AND SUPPORTS to be designed and tested to sustain load 8 times actual supported load.

H545 HANGERS AND SUPPORTS to be steel with smooth flat bearing surfaces, to carry weight of piping and contents without sagging, swaying, vibrating or deforming, and allowing free movement of pipes due to expansion and contraction without noise or damage to piping or construction.

H547 HANGERS AND SUPPORTS to be complete with all necessary structural steel, rods, bolts, nuts, turnbuckles and other components.

H550 SUPPORTS FOR HORIZONTAL CAST IRON PIPES to be double bolt clamp type with 20 mm diameter hanger rod threaded one end and with formed eye other end, attached to structural U- channel with mounting nut.

H560 SUPPORTS FOR VERTICAL CAST IRON PIPES to be bolted clamp with long legs resting on concrete slab or bolted to structural iron angle cast into wall.

H565 PIPE PROTECTION SADDLES for use on insulated hot pipes to be galvanized sheet steel 300 mm long, approximately 60 degrees of arc, 3 mm thick for pipes up to 125 mm and 5 mm thick for pipes over 125 mm.

H570 INSULATION PROTECTION SHIELDS for use on insulated cold pipes to be galvanized sheet steel 300 mm long, to fit outside diameter of insulation and cover 180 degrees of arc, 3 mm thick for pipes up to 125 mm and 5 mm thick for pipes over 125 mm.

H575 PIPE ANCHORS AND GUIDES: 20 mm diameter U-bolts to fit around pipe loosely for guides and welded to pipe for anchors.

H580 DISMANTLING JOINT, FLANGE ADAPTORS AND COUPLINGS shall be installed according to the drawings. Dismantling joint and flange adaptors shall be allowed a minimum movement of at least +/- 25mm. Material of dismantling joints, flanges adaptors and couplings shall be as follows.

H581 DISMANTLING JOINT, FLANGE ADAPTORS AND COUPLINGS: Flanges sleeve and follower shall be made of Ductile Iron. Anchor bolts, studs, nuts and washers shall be made of stainless steel grade A4 / 316. Rubber sealing ring shall be EPDM trapezoidal wedge type. Minimum shore hardness 70. Construction shall be all steel with flanges class PN 10.

WORKMANSHIP

412:1 PIPEWORK GENERALLY

1001 INSTALL pipework in accordance with best engineering practice to present a neat, pleasing appearance. Vertical pipes to be plumb and horizontal pipes pitched up in direction of flow to allow proper venting and drainage.

1051 GROUP pipes together where practicable and run in straight parallel lines close and parallel to walls, ceilings and columns.

1101 CLEARANCE: leave adequate clearance between pipes and adjacent pipes, walls, ceilings and columns for making joints properly, easy installation and revalves and accessories and proper installation of insulation and individual pipe hangers and supports.

1151 ACCESSIBILITY: install concealed piping to permit easy accessibility for maintenance and repair, particularly of valves, vents, drains and other accessories.

1201 AIR POCKETS: install piping to avoid air pockets and dirt traps.

1202 AIR POCKETS: use eccentric reducers where appropriate to avoid air pockets, with flat of reducer on top on water piping to permit proper venting of system.

1251 EXPANSION AND CONTRACTION: install piping to permit free expansion and contraction without damage to piping or structure. Provide adequate offsets and changes of direction to accomplish this and on long runs provide expansion loops or expansion joints.

1252 EXPANSION AND CONTRACTION: where pipe loops or changes in direction cannot be employed to absorb thermal movement provide expansion joints and pipe anchors and guides.

1301 INSPECTION: do not paint, cover or enclose piping until it is tested, inspected and approved.

1351 JOINTS: cut pipes square and to exact length with a hacksaw. Ream cut end with a special tool to full inside diameter and remove chips.

1401 THREADED JOINTS: threads to be cut to British Standard Taper Pipe Thread. Cut threads with new dies and remove burrs and chips with wire brush.

1402 THREADED JOINTS: make up tight close to shoulder of male thread. Use Teflon tape, thread sealant or other approved special jointing compound.

1403 THREADED JOINTS: make with red lead on cold pipes and with graphite ground in linseed oil on hot pipes. Apply to male thread only. Teflon tape thread sealant may be used.

1451 FLANGED JOINTS: make perfectly square with pipe, fit with rings gaskets and assemble with steel square head machine bolts and hexagonal nuts.

1501 PIPE UNIONS OR FLANGES: provide at connections to equipment, near valves, controls, strainers and other accessories requiring removal.

1502 PIPE UNIONS OR FLANGES: provide at adequate intervals in piping to permit easy disassembly.

1503 PIPE UNIONS OR FLANGES: fit between valves and equipment to permit removal of equipment without disturbing piping.

1551 EXPANSION JOINTS: when used give consideration to anchoring and guiding pipes for controlled expansion and contraction. Follow instructions of manufacturer.

1601 JOINTS BETWEEN DISSIMILAR METALS: make through dielectric insulated unions and flanges. Use unions on threaded piping and flanges on welded piping.

1651 FITTINGS: changes in direction and size, branching and jointing of pipes are to be made with regular pipe fittings. Do not bend pipe.

1652 FITTINGS: field fabricated fittings, bushings, close nipples and street elbows will not be allowed.

1701 CONNECTIONS TO MOVING EQUIPMENT: make through flexible connections. Provide shut-off valves on both sides of equipment. Make any reductions in pipe size at equipment connections with all pipe accessories of same size as pipe runs.

1751 CLEANING: clean equipment, materials and piping on inside and outside from loose mill scale, blisters, sand, plaster, paint droppings, dirt, oil, grease, labels and all foreign matter.

1752 CLEANING: wire brush piping on outside before painting or covering.

1801 CLEANING WATER SYSTEMS: after completing each section clean pipes, fittings, valves and accessories internally by flushing with clean water.

1851 CLEANING AIR OR GAS SYSTEMS: after completing each section clean pipes, fittings, valves and accessories internally by blowing with compressed air.

412:2 PIPEWORK SUPPORT - GENERALLY

2001 SUPPORT piping independently of equipment.

2002 SUPPORT piping at intervals to avoid air pockets and dirt traps.

2051 SPANS: specified maximum spans are for straight runs of pipe.

2061 LOCATE supports to carry weight of pipe, valves, fittings, insulation, appurtenances and contents without sagging.

2101 LOCATIONS: in addition to maximum spans specified, location of supports and hangers is to take into account concentrated loads, elimination of overhung sections or bends, load reaction on terminal connections, pipe expansion and contraction, vibrations, hydrostatic testing, water hammer and seismic forces.

2102 LOCATIONS: reduce spacing of supports to less than three quarters of maximum spans specified where changes in direction or branch connections occur.

2103 LOCATIONS: locate supports immediately adjacent to changes in direction of piping, branch connections and concentrated loads irrespective of maximum spans specified.

2151 SUPPORT RISERS independently of adjacent horizontal hangers.

2201 FIX supports to structure with masonry expansion bolts without causing overstress to structure.

2211 INTERMEDIATE STEEL ELEMENTS: provide where required to transfer loads to areas of structure where they can be safely accommodated.

2251 MASONRY EXPANSION BOLTS: drill in structure and install in accordance with manufacturer's instructions.

2301 MULTIPLE PIPING RUNS: where bottoms of lines are approximately at same level, support in groups on trapeze hangers. Keep pipes in position with U-bolts. Lines subject to extreme thermal expansion to be free to slide or roll.

2351 TRAPEZE HANGERS: maximum spacing to be that for smallest pipe supported.

2401 SPRING CUSHIONS: use where horizontal pipe is subject to considerable vertical movement or vibration.

2421 INSULATED PIPES: protect insulation at hanger or support from weight or movement of pipe. Provide firm attachment of pipe.

2431 INSULATED HOT PIPES to be supported with pipe clamp directly on pipe with arms of clamp extended outside the insulation or with clevis hanger or pipe clamp lined with insulation protection shields.

2451 PROTECTION SHIELDS: use to protect insulated pipes at hangers and supports.

2461 EMBEDDED INSERTS: install during concreting.

2501 ANCHORS: weld U-bolts to pipes at points of contact and bolt to structural angle frame securely fixed to structure.

2551 TEMPORARY HANGERS AND SUPPORTS will not be allowed. Do not use wire, metal bands, rope, wood, chain, strap or perforated bar. Do not hang pipes from other pipes.

412:3 FERROUS PIPEWORK

3051 HORIZONTAL CAST IRON PIPES: support at every joint, at base of each vertical stack, at each change in direction, at each branch connection and at not more than 1.5 m spaces on straight runs.

3052 HORIZONTAL CAST IRON PIPES: securely attach U-channel support to structure with 20 mm masonry expansion bolts.

3101 VERTICAL CAST IRON PIPES: support at a minimum of each storey height.

3151 DUCTILE IRON PIPES: support with at least one support per length of pipe and at intervals not exceeding 3.5 m with hanger preferably located adjacent to joint.

3201 HORIZONTAL STEEL PIPES: support at intervals not exceeding maximum support spacing and by hanger rod of minimum size as follows:

| Pipe Diameter mm | Maximum Support Spacing m | Minimum Size of Hanger Rod mm |
|---|---|---|
| 15 | 1.5 | 10 |
| 20 | 1.8 | 10 |
| 25 | 2.0 | 10 |
| 32 | 2.5 | 10 |
| 40 | 2.7 | 10 |
| 50 | 3.0 | 10 |
| 65 | 3.3 | 13 |
| 80 | 3.6 | 13 |
| 100 | 4.2 | 16 |
| 125 | 4.8 | 16 |
| 150 | 5.2 | 22 |
| 200 | 5.8 | 25 |

3251 VERTICAL STEEL PIPES: support at a minimum of every storey height.

3351 CUT CAST IRON PIPES with hacksaw.

3401 JOINT SOCKETTED CAST IRON PIPES by caulking.

3402 JOINT SOCKETTED CAST IRON PIPES using neoprene gasket:

Man: Brickhouse Broads (U.K.)
Ref: model S4001

or approved equal.

3451 CAULKED JOINTS: firmly pack with oakum or hemp gasket and fill at one pouring with molten pig lead to a depth not less than 25 mm and not extending more than 3 mm below rim of socket. When lead has cooled to room temperature ram with special blunt caulking tool.

3452 CAULKED JOINTS between steel and cast iron pipes to be made as described above. Pipe coupling is to be screwed to threaded end of steel pipe to act as caulking ferrule.

3460 JOINT SOCKETLESS CAST IRON PIPES using couplings conforming to the requirements of BS EN 877, with nitrite rubber gasket to BS EN 682, BS EN 681-2, BS 7874 (1998) and BS EN 681-1 and stainless steel screws and nuts to BS EN 10089.

3501 FLANGED JOINTS IN DUCTILE IRON PIPE: do not cut flanged pipes to fit required lengths. Use special flanged short pieces.

3502 FLANGED JOINTS IN DUCTILE IRON PIPE: where flanged short pieces of standard length do not close gap left between flanges, use spend distance pieces or pipe blocks of same material and pressure class as pipes.

3503 FLANGED JOINTS IN DUCTILE IRON PIPE: use special long tie bolts with two nuts to bolt flanges together with distance piece or pipe block between. Distance piece to be gasketed at both ends to flanges.

3504 FLANGED JOINTS IN DUCTILE IRON PIPE: where flanges on equipment do not match pipe or fitting flanges provide approved flanged steel adaptors.

3551 JOINTS IN BLACK STEEL PIPES 50 mm diameter and under to be threaded and in pipes over 50 mm diameter to be welded.

3601 JOINTS IN GALVANIZED STEEL PIPES to be threaded.

3701 WELDED JOINTS: electric arc welded. Pipes not exceeding 100 mm diameter may be welded by oxy-acetylene torch.

3702 WELDED JOINTS: pipes to be cleaned free from rust, scale and oxide and bevelled for V-butt weld.

3751 WELDS to be of sound metal and free from laps, gas pockets, slab inclusions, interior protrusions and other imperfections.

3752 WELDS: hammer clean and flush out piping to remove scale, welding slag and other debris.

3801 WELDERS to be of first class ability with long experience in the trade. Submit names and full qualifications for approval. Welders will be required to demonstrate their ability by welding pipe joint samples before being accepted for the work.

3851 BLACK FITTINGS: not allowed on galvanized pipes.

3901 WELDOLETS AND THREADOLETS of forged steel may be used on black steel pipe branch connections where branch does not exceed half diameter of main pipe.

## 412:6 PVC PIPEWORK

6001 STORAGE: handle pipes with care. Store in the shade. Support along entire length on level ground free from loose stones. Do not stack more than three layers high. Place sockets at alternate ends of stack and protruding beyond pipes. Stake stacks to prevent movement. For long term storage provide pipe racks with continuous supports. Comply with manufacturer's recommendations for storage.

6051 PIPES AND FITTINGS to have cleanly cut square ends. Pipes to be reasonably straight.

6101 JOINTS: make rubber ring joints or welded solvent joints in accordance with manufacturer's instructions. Use solvent made and supplied by manufacturer.

6151 ABOVE GROUND SUPPORTS: provide at intervals not exceeding maximum spacing as follows:

| Pipe Diameter mm | Maximum Support Spacing Horizontal mm | Vertical mm |
|---|---|---|
| 15 | 600 | 1200 |
| 20 | 700 | 1400 |
| 25 | 750 | 1500 |
| 32 | 800 | 1600 |
| 40 | 900 | 1800 |
| 50 | 1050 | 2100 |
| 82 | 1350 | 2700 |
| 110 | 1500 | 3000 |
| 160 | 1800 | 3600 |

6152 ABOVE GROUND SUPPORTS: pipes to be well supported but not tightly clipped to allow freedom of movement except at anchors. Use soft rubber or other flexible membrane between pipe and clip. Anchor at changes in direction and at valves. Accommodate thermal movement by expansion joints or bellows. Comply with manufacturer's recommendations for above ground supports.

6201 UNDERGROUND PIPES: anchor at changes in direction and at valves and stop ends.

6211 UNDERGROUND PIPE EXCAVATION: trench is not to be open too far in advance of pipe laying and then back-filled as soon as possible.

6221 UNDERGROUND PIPE BEDDING: use free draining sand, gravel, loam or soil. Compact fill firmly between side of pipe and trench. Bedding to be thoroughly compacted in layers not exceeding 150 mm to give uniform bed. Lay pipes directly on bedding. Do not use brick or hard material under pipe. Further bedding material to be placed around pipe and thoroughly compacted in 75 mm layers by careful tamping.

6231 UNDERGROUND PIPE: backfill trench above pipe in layers 300 mm thick each layer well rammed.

6232 UNDERGROUND PIPE: comply with manufacturer's recommendations for laying underground pipe.

6301 SPECIAL ADAPTORS: use for connecting PVC pipes and fittings to pipes of other materials.

## 412:7 POLYPROPYLENE PIPEWORK

7001 STORAGE: handle pipes with care. Store in the shade to avoid direct exposure to ultra violet rays. Comply with manufacturer's recommendations for storage.

7051 PIPES: cut perfectly square using a mitre box, and tube cutter or hacksaw; remove all burrs from both inside and outside of pipe using a reamer and file, taking care not to expand the pipe while reaming. Clean the inside of joint fitting cup and the outside of the pipe to one and a half times the depth of insertion into the joint fitting. Cleaned surfaces shall not be touched by hands or gloves. Polypropylene pipework shall be round, smooth and free from defects and deletrious films in the bore and, unless otherwise indicated, shall be jointed and connected by electric welding.

7151 INSTALLATION IN CONCRETE AND IN WALLS: pipework installed in concrete shall have the ability to absorb expected changes in length due to thermal expansion. All pipelines running in walls or under tile, with a straight length of more than 2 m, shall be covered with insulated foam sleeve in order to absorb axial expansion, and avoid condensation and noise transmission.

When thermal expansion is expected for pipes installed without insulation in walls or under tile, install a plastic material, such as polystyrene, at points of change in pipeline direction.

A. Install hangers for Polypropylene plastic piping with the following maximum spacing and minimum rod diameters:

   1. DN25 and Smaller: Maximum horizontal spacing, 900 mm with 10-mm minimum rod diameter; maximum vertical spacing, 1500 mm.
   2. DN32 to DN50: Maximum horizontal spacing, 1200 mm with 10-mm minimum rod diameter; maximum vertical spacing, 1800 mm.
   3. DN65 to DN90: Maximum horizontal spacing, 1200 mm with 13-mm minimum rod diameter; maximum vertical spacing, 1800 mm.
   4. DN100 and DN125: Maximum horizontal spacing, 1200 mm with 16-mm minimum rod diameter; maximum vertical spacing, 1800 mm.
   5. DN150: Maximum horizontal spacing, 1200 mm with 19-mm minimum rod diameter; maximum vertical spacing, 1800 mm.
   6. DN200: Maximum horizontal spacing, 1200 mm with 22-mm minimum rod diameter; maximum vertical spacing, 1800 mm.

412:8 ABOVE GROUND SUPPORTS: provide at intervals not exceeding maximum spacing as follows:

| Pipe Diameter mm | Maximum Support Spacing Horizontal mm | Vertical mm |
|---|---|---|
| 15 | 600 | 1200 |
| 20 | 700 | 1400 |
| 25 | 750 | 1500 |
| 32 | 800 | 1600 |
| 40 | 900 | 1800 |
| 50 | 1050 | 2100 |
| 82 | 1350 | 2700 |
| 110 | 1500 | 3000 |
| 160 | 1800 | 3600 |

## 412:9 FLUSHING AND DISINFECTION OF WATER PIPES

9101 PROCEDURE: to AWWA C651.

9161 PROVIDE equipment, gauges, temporary connections and chlorine needed for flushing and disinfection. Water needed for flushing and disinfection is to be provided by Contractor.

9201 SECTIONS: flush and disinfect pipes in sections as directed by the Engineer.

9211 DRAINING: use drain valves and low points to drain flushing and disinfecting water.

9221 FIRST FLUSHING: before commencing disinfection, flush pipes until effluent is clean and then clean as directed. 1 to 2 times volume of pipe is usually required for such flushing.

9231 TYPE OF CHLORINE: disinfect with liquid chlorine or calcium hypochlorite or sodium hypochlorite and agree with the Engineer on method of application.

9241 INITIAL DOSING is to be 50 ppm.

9251 CONTACT PERIOD is to be 24 hours.

9261 RESIDUAL CHLORINE: measure residual chlorine by orthotolidin test. Residual chlorine is not to be less than 5 ppm or test is to be repeated as directed.

9271 FINAL FLUSHING: after disinfection, reflush network until chlorine concentration in water leaving network is less than 1 ppm.

9281 TESTS: perform bacteriological tests to AWWA C651, Section 7.

9301 ENVIRONMENT: if, in the opinion of the Engineer, there is any possibility that chlorinated discharge will cause damage to the environment, then a neutralizing chemical shall be applied to the wasted flushing and disinfecting discharge water.

# 413 COMPONENTS AND ACCESSORIES

## PRODUCTS

### 413:X COMPONENTS AND ACCESSORIES

### 413:X1 VALVES - GENERALLY

X105 SIZE: to be same as pipe run.

X110 RATING: 860 kPa steam working pressure rating and 1380 kPa cold water non-shock pressure rating, unless otherwise specified.

X115 MANUFACTURERS: obtain valves from one of the following:

| | |
|---|---|
| Crane | (U.S.A.) or (U.K.) |
| Dezerick | (U.K.) |
| Econosto | (Holland) |
| Lunkenheimer | (U.S.A.) |
| Newman Hattersley | (U.K.) |
| Nibco Inc. | (U.S.A.) |

or approved equal.

X120 SUBMISSIONS: approval of manufacturer does not necessarily constitute approval of his valves. After award of Contract and prior to start of construction submit for approval a complete summary of valves proposed indicating service, manufacture, figure number, type and pressure rating.

X125 THREADED VALVES to have British Standard Taper Pipe Thread.

X130 GATE AND GLOBE VALVES to be capable of being repacked under pressure.

### 413:X2 ISOLATING VALVES

X210 GATE VALVES 50 mm diameter and under to be screwed, with bronze body and trim, solid wedge disc, non-rising stem and screwed bonnet.

X211 GATE VALVES over 50 mm diameter to be flanged, with cast iron body, bronze trim, solid wedge disc, non-rising stem and bolted bonnet.

X220 BALL VALVES 50 mm diameter and under to be full port of two-piece construction, lever operated; having bronze body and stem, chrome-plated brass ball, replaceable PTFE seats and packing and plastic coated steel handle; with threaded end connections for steel piping, and copper compression or solder end connections for copper piping.

413:X3 GLOBE VALVES

X310 GLOBE VALVES 50 mm diameter and under to be screwed, with bronze body and trim, integral seat, revolving disc, inside screw, rising stem and screwed bonnet.

X311 GLOBE VALVES over 50 mm diameter to be flanged, with cast iron body, bronze trim, renewable seat and disc, outside screw, rising stem and bolted bonnet.

413:X4 CHECK VALVES

X410 CHECK VALVES 50 mm diameter and under to be screwed, with bronze body and trim, swing pattern, renewable composition disc and screwed cover.

X411 CHECK VALVES over 50 mm diameter to be flanged, with cast iron body, bronze trim, swing pattern, renewable seat and bolted cover.

X430 SILENT CHECK VALVES to be non-slam, spring loaded and suitable for installation in any position.

X431 SILENT CHECK VALVES 50 mm diameter and under to be screwed, with bronze body, seat and disc, 18-8 stainless steel spring, with body having 2070 kPa working pressure rating.

X432 SILENT CHECK VALVES over 50 mm diameter to be flanged, with cast iron body, bronze seat and disc, 18-8 stainless steel spring, with body having 1720 kPa working pressure rating.

X433 SILENT CHECK VALVES to have straight guided disc with two-point bearing. Wearing parts including disc, seat and other guide bushing to be replaceable.

X434 SILENT CHECK VALVES to have flow area in excess of pipe area for minimum pressure drop.

X435 SILENT CHECK VALVES: obtain from one of the following:

| | |
|---|---|
| Apco | (U.S.A.) |
| Crane | (U.K.) |
| Mueller | (U.S.A.) |

or approved equal.

X441 WEIGHTED CHECK VALVES to have outside lever and weight arranged to assist disc in closing. Lever to be malleable iron, keyed and locked to extended hinge pin of valve which is to project from one side of valve body through special pressure tight stuffing box. Weight to be cast iron, locked to lever with set screw so that moving parts operate together.

## 413:X7 PRESSURE REDUCING VALVES

X705 PRESSURE REDUCING VALVES: pressure reducing valves of size, capacity and pressure to match with required system pressure. Factory-set for specified limits with easy adjustment on site.

X710 TYPE: valve to be equipped with a low-inlet pressure check valve and removable strainer. All wetted parts are made out of brass. Valve seat, strainer and stem must be removable.

X715 MANUFACTURER: obtain valve form one of the following:

| | |
|---|---|
| ITT Bell & Gosett | (U.S.A.) |

or approved equal.

## 413:X10 OTHER VALVES

X1010 RELIEF VALVES: spring loaded, angle type with screwed or flanged ends to suit pipe, male bottom inlet, female side outlet, bronze body and trim, suitable for 1030 kPa steam working pressure, complete with hand lever and preset at factory with pressure setting clearly stamped on nameplate.

X1011 RELIEF VALVES: obtain from one of the following:

| | |
|---|---|
| Apco | (U.S.A.) |
| Crane | (U.S.A.) or (U.K.) |
| Newman Hattersley | (U.K.) |

or approved equal.

X1020 FLOAT VALVES 50 mm diameter and under to have screwed inlets and over 50 mm diameter to have flanged inlets.

X1021 FLOAT VALVES to be all bronze construction including levers and arms, with copper float and suitable for 1030 kPa cold water working pressure.

X1022 FLOAT VALVES: full bore, equilibrium ball type, designed to close tight against maximum pressure when half submerged, with renewable, synthetic rubber, valve disc and balancing piston bucket.

X1023 FLOAT VALVES: obtain from the following:

| | | |
|---|---|---|
| Man: | Newman Hattersley | (U.K.) |
| Ref: | No. 329 for screwed inlet;<br>No. 328E for flanged inlet | |

or approved equal.

X1030 MANUAL DRAIN VALVES: gate valve 20 mm diameter minimum size with brass serrated hose connection at outlets.

X1035 MANUAL AIR VENTS: globe valve 15 mm diameter minimum size

X1040 AUTOMATIC AIR VENTS: float type with brass base and connection tail. Body, cover, float and vacuum breaker of high quality temperature resisting synthetic material, suitable for working pressure of 600 kPa and temperature of 168 deg. C.

X1041 AUTOMATIC AIR VENTS: obtain from the following:

| | |
|---|---|
| Apco | (U.S.A.) |
| Honeywell Braukmann | (Germany) |

or approved equal.

X1045 AUTOMATIC AIR ADMITTANCE VALVE: uPVC type helps prevent the syphonage of traps in a soil and waste system. When a plumbing fixture is operated, negative pressure causes the valve to open, allowing air to enter and equalize pressure. When the flow stops, gravity closes the valve. Obtain from the following:

| | |
|---|---|
| Terrain | (U.K.) |
| Studor | (U.S.A.) |

or approved equal.

413:Y1 INSTRUMENTS

Y110 PRESSURE GAUGES to be Bourdon tube type, with minimum 100 mm dial diameter, flangeless back, 15 mm male threaded bottom connection, black finished, cast aluminium case, threaded black epoxy finished cast aluminium ring, gasketted glass face, type 316 stainless steel spring tube, stainless steel precision movement and micrometer adjustment on needle.

Y111 PRESSURE GAUGES to be graduated in kg per square centimetre with 1 kg/cm2 divisions. Accuracy to be plus or minus one percent, and range not less than two times operating pressure.

Y112 PRESSURE GAUGES to be provided complete with 8 mm diameter brass tube siphon with snubber and cock.

Y114 PRESSURE GAUGES: obtain from one of the following:

| | |
|---|---|
| Ashcroft | (U.S.A.) |
| Taylor Instrument Co. | (U.S.A.) |

or approved equal.

Y120 THERMOMETERS: mercury in glass type, 150 mm minimum length, brass protective cover, brass separable socket well and graduated with 1 deg. C divisions.

Y121 THERMOMETERS: obtain from one of the following:

| | |
|---|---|
| Palmer Thermometers | (U.S.A.) |
| Taylor Instrument Co. | (U.S.A.) |

or approved equal.

## WORKMANSHIP

### 413:1 GENERALLY

1051 THREADED VALVES: exercise care in installing to avoid straining valve bodies.

1052 THREADED VALVES: when attaching pipe to valve in place, use second wrench to hold valve pipe is being tightened. To avoid damage to seat do not screw pipe too far into valve.

1101 GATE VALVES: do not use for throttling purposes such as regulations, balancing or controlling. Use only for shut- off purposes with valve either fully closed or fully open.

1151 GLOBE VALVES: use where throttling service is required.

1201 MANUAL DRAIN VALVE: fix at all low points of water piping systems whether shown on the Drawings or not.

1251 MANUAL OR AUTOMATIC AIR VENTS: fix at all high points of water piping systems.

1301 ISOLATING VALVES: provide on all water piping system branches.

1351 CHECK VALVES on discharge of pumps are to be silent type. Those over 80 mm are to be weighted.

1401 STRAINERS: provide upstream of pumps, control valves, and other equipment that can be damaged by suspended particles in the fluid.

# 414 PUMPS

## PRODUCTS

### 414:A GENERALLY

A105 MOTORS: supply pumps complete with electric motors. Horizontal base mounted pumps to have motor mounted on common cast iron or steel base properly aligned at factory.

A110 SHAFT PACKING OR MECHANICAL SEALS to be compatible with pump design and nature of liquid pumped, in accordance with manufacturer's recommendations.

A115 IMPELLERS AND ROTATING ASSEMBLIES to be statically and dynamically balanced at factory.

A120 PLUGGED CONNECTIONS to be provided for casing vent, drain and suction and discharge pressure gauges.

A125 OPERATING POINT OF FLOW AND HEAD is to fall near point of maximum efficiency obtained from manufacturer's published data. Do not select pumps to operate near the end of their curve.

A130 HORSEPOWER RATING OF ELECTRIC MOTOR is to ensure non- overloading throughout capacity range of pump.

A135 ELECTRIC MOTORS to be supplied for available current. Speed is not to exceed 1450 rpm unless otherwise specified.

A140 SUBMISSIONS: submit the following for approval for each pump prior to shipment:

certified performance curves showing job number, customer, customer order number, pump designation number shown on the Drawings, date of manufacture, model number, pump size, impeller diameter, impeller type, maximum impeller diameter pump can accommodate, rpm, flow-head characteristic curve, consumed horsepower curve, pump efficiency curve parts numbers and parts lists

outline dimensional drawing showing overall dimensions, location of foundation bolt holes and size, location and rating of suction and discharge nozzles

recommended list of spare parts

installation, operation and maintenance instruction manual

details and wiring diagrams of pump controllers, starters, controls or other electrical device or accessory

special instructions for installation and connection of each electrical device, control or accessory

motor data such as make, model number, serial number, horsepower rating, rpm, voltage, phase, frequency, class of insulation, allowable temperature rise, full load amperes and locked rotor amperes

starter data such as make, model number, size, heater sizes, ampere rating, line voltage, control voltage and frequency.

## 414:J CLEAR WATER PUMPS

### 414:J1 END SUCTION CENTRIFUGAL PUMP

J105 TYPE: horizontal, base mounted, end suction, single stage, centrifugal type, directly connected to motor through heavy duty flexible coupling, with heavy gauge coupling guard.

J110 BASE: pump and motor to be mounted on common cast iron or steel base reinforced against deflection, with drip rim, drain tapping, bolt holes and grouting hole.

J115 PUMP CASING: high tensile strength close grain cast iron with smooth waterways, register fitted and bolted to bearing frame for permanent alignment, with bronze wear rings and tapped and plugged bottom drain and top vent connections.

J120 IMPELLER: cast iron, enclosed type, fitted to shaft with key and locked in place.

J125 SHAFT: one piece stainless steel, sized to carry axial and radial thrust with minimum deflection.

J130 MECHANICAL SEAL: Ni-resist face, carbon washer and stainless steel metal parts.

J135 BEARINGS: pump rotating element to be supported by two heavy duty grease lubricated ball bearings mounted in heavy iron frame with supports to base for maximum rigidity.

J140 ELECTRIC MOTOR: totally enclosed, squirrel cage, induction type with permanently lubricated and sealed ball bearings.

J145 MANUFACTURERS: obtain pump from one of the following:

| | |
|---|---|
| Aurora Pumps | (U.S.A.) |
| Goulds Pumps | (U.S.A.) |
| ITT Bell & Gossett | (U.S.A.) |
| KSB | (Germany) |
| Paco Pumps | (U.S.A.) |
| Peerless Pump | (U.S.A.) |
| Pullen Pumps | (U.K.) |
| Ritz | (Germany) |
| Taco Pumps | (U.S.A.) |
| Worthington | (U.S.A.) or (U.K.) |
| Weir Pumps | (U.K.) |

or approved equal.

## 414:J6 CONSTANT PRESSURE PUMPING UNIT

J605 COMPONENTS: one jockey pump and two main pumps completely assembled on steel frame, with all components piped, wired and tested at factory and delivered as a complete packaged unit ready for installation. Frame to have holes for anchor bolts and adequate grout volume.

J610 ACCESSORIES: suction and discharge header piping, flexible connection, individual pump suction and discharge shut-off valves, check valves on each pump discharge, suction and discharge pressure gauges, pressure reducing valves and electric control panel.

J615 CAPACITY AND PRESSURE MODULATION to be by cycling pump operation and reliable pressure reducing valves. Pumps to be cycled by current sensing relays with provision for electrical alternation of the two main pumps. Pump motor controls to be interlocked so that failure of any pump or motor in unit will automatically sequence remaining pumps.

J620 PUMPS: close-coupled, horizontally mounted, centrifugal type, driven by electric motors. Pump casing and back cover to be close grain cast iron, impeller to be machined bronze casting and pump shaft to be stainless steel. Pumps to be fitted with self-adjusting mechanical seals with carbon rotating face running against stationary ceramic seat.

J625 ELECTRIC MOTORS: totally enclosed, fan cooled, squirrel cage, induction type with permanently lubricated seats and ball bearings.

J630 INTERCONNECTING PIPING: galvanised steel.

J635 VALVES: screwed, bronze body and trim, 1030 kPa steam pressure rating.

J640 ELECTRIC CONTROL PANEL to be heavy gauge steel sheet finished with stoved hammer paint internally and externally and containing necessary motor starters, circuit breakers, door fitted isolating switch, selector switches, indicator lights, automatic alternation of two main pumps, necessary relays and accessories to provide required sequence of control, low suction pressure cut-out, low water level electrodes and audio visual alarm.

J645 MANUFACTURERS: obtain unit from one of the following:

| | |
|---|---|
| ITT Bell & Gossett | (U.S.A.) |
| Paco Pumps | (U.S.A.) |
| Pullen Pumps. | (U.K.) |

or approved equal.

## 414:J7 PRESSURISED WATER SUPPLY PUMPING UNIT

J705 COMPONENTS: unit to be packaged type comprising two pumps, membrane tank, interconnecting pipe work, valves, pressure switches and electric control panel all completely assembled on steel frame, piped, wired and tested at factory and delivered as complete packaged unit ready for installation and operation with simple piping and electrical connections.

J710 OPERATION: unit to be automatically controlled by pressure switches starting pumps on fall of pressure in tank and stopping pumps on rise of pressure. Pumps to be sized so that both pumps running together would supply maximum demand specified. Under normal conditions one pump is to supply sufficient water with second pump acting as back up and standby. Controls are to automatically start second pump when one pump is unable to supply demand.

J715 PUMPS: close-coupled, centrifugal, single stage type, horizontally mounted and driven by electric motors, fitted with self-adjusting mechanical seals with carbon rotating face running against stationary ceramic seat. Casing and mechanical seal housing to be close grain cast iron, impeller to be bronze and shaft to be stainless steel.

J720 ELECTRIC MOTORS: totally enclosed, fan cooled, squirrel cage, induction type with permanently lubricated and sealed ball bearings.

J725 MEMBRANE TANK is to contain removable rubber bag and be pre-charged with air at factory to correct pressure to provide sealed air cushion eliminating use of an air compressor. Tank to have air valve of type to permit recharging on site by small hand compressor or simple car tyre pump. Rubber bag to be guaranteed by manufacturer for use on pumped fluid without deterioration with time and without bursting. Tank to be welded mild steel plate for operating pressure of 1000 kPa, with cylindrical shell and convex dished ends, shot blasted and painted internally with bitumastic paint and externally with zinc primer and hammer enamel paint.

J730 INTERCONNECTING PIPING: galvanised steel.

J735 VALVES: screwed, bronze body and trim, 1030 kPa steam working pressure rating. Each pump to have non-return valve at discharge and individual suction and discharge shut-off valves.

J740 DISCHARGE MANIFOLD to have pressure switches, pressure gauge and vent cock.

J745 ELECTRIC CONTROL PANEL to be heavy gauge mild steel sheet finished with stoved hammer paint internally and externally. It is to contain, but is not necessarily limited to, the following:

main isolating switch mechanically interlocked to front door to prevent access to live parts
motor starters
adjustable overload relays
pressure switches
pressure gauge
indicator lights
low suction pressure cut-out
interconnecting and interlock wiring.

J750 MOUNTING FRAME to be mild steel hollow section members protected with anti-corrosion paintwork.

J755 MANUFACTURERS: obtain unit from:

| | |
|---|---|
| ITT Bell & Gossett | (U.S.A.) |
| Pullen Pumps | (U.K.) |

or approved equal.

## 414:K WASTE WATER AND SOILED WATER PUMPS

### 414:K3 DUPLEX SUBMERSIBLE SEWAGE PUMPS

K305 TYPE: non-clog, centrifugal, submersible, quick- disconnect type, designed to permit ground-level removal from pit without disconnecting or disturbing discharge pipe or electrical connections. Design is to permit pump when lowered into place to connect automatically to discharge elbow in a tight, leak-proof manner without axial or lateral movement or further adjustment.

K310 ACCESSORIES: close-coupled, submersible, vertical electric motor, required length of durable multi-conductor electric cable, quick-disconnect flanged discharge elbow with integral bracket for floor mounting, lower guide rail holder, galvanised steel guide rails, upper guide rail bracket, rail guided lifting assembly, lifting yoke, galvanised chain for raising and lowering pump, odour tight double opening access covers and frames, electric control panel and four level regulators.

K315 OPERATION: automatic, level regulator operated, alternating start-up sequence. One pump to be for normal flow with other pump on standby. Standby pump to start if abnormal flow exceeds one pump capacity and in event of fault in other pump. Level regulators are to start and stop pumps at pre-set levels through the control panel. Alarm level regulator located vertically midway between starting regulators is to be actuated in event of defect in one pump or if flow exceeds capacity of one pump.

K320 CONSTRUCTION: cast iron casing and cast iron impeller. Impeller to be non-clog, designed to pump raw unscreened sewage and waste products and pass solids up to 76 mm diameter. Other internal parts to be stainless steel.

K325 ELECTRIC MOTOR: totally enclosed type designed for use in hazardous locations, rated for continuous duty, with cast iron frame, stainless steel shaft, mechanical shaft seals, built-in thermal overload protection and moisture sensing probes.

K330 PUMP AND MOTOR BEARINGS: heavy-duty, permanently lubricated and sealed ball bearings, guaranteed for minimum 100,000 hours continuous operation.

K335 DISCHARGE ELBOW FLANGE to be faced and drilled to ISO 13 standard.

K340 LEVEL REGULATORS: pear-shaped type, with internal micro-, weighted to be vertical in air and horizontal in water without floating. One for dry running protection for the two pumps, one to be for stopping, one for starting the duty pump and one for starting the standby pumps and initiate high level alarm.

K341 LEVEL REGULATORS to have as needed contacts for starting or stopping motor, length of three-core electric cable and holder designed to guide and support power and level regulator cables.

K342 LEVEL REGULATORS: casing and cable insulation to be non-corrodible, suitable for operation in and resistant to raw sewage.

K345 ALARM BELL: provide to give audible alarm of high water level.

K350 CONTROL PANEL: weatherproof with lockable cover, completely assembled, wired and tested at factory ready for installation with simple external connections.

K351 CONTROL PANEL to contain starters, over-riding starter buttons, indicating lamps for pump in operation and in fault, reset buttons for overload relays, electric alternator for two pumps, manual/auto selector switch, 24-volt control circuit transformer, running hours meters and accessories for automatic operation of pumps

K360 MANUFACTURERS: obtain unit from one of the following:

| | |
|---|---|
| Flygt | (U.K.) |
| Paco Pumps | (U.S.A.) |

or approved equal.

414:K4 SUBMERSIBLE SUMP PUMP

K405 TYPE: submersible, portable, centrifugal type, forming single compact unit with its motor, to rest on sump floor on combined base and suction strainer and finished with black, non-hardening, corrosion resistant, rubber-bitumen paint.

K410 ACCESSORIES: three level regulators, lengths of durable multi-conductor electric cable, holder for level regulators and control panel.

K415 CONSTRUCTION: cast iron casing with integral threaded discharge elbow, cast iron impeller and motor stator housing and stainless steel shaft, nuts and bolts. Pump to have clamp for discharge pipe, watertight cable entry, two double face mechanical seals, oil casing to lubricate and cool seal rings, bronze case wear rings and bronze terminal cover.

K420 ELECTRIC MOTOR: j (totally enclosed, drip-proof) type with two thrust ball bearings and with stator insulated to Class F against moisture and heat.

K425 LEVEL REGULATORS: pear-shaped type, with internal micro switch, weighted to be vertical in air and horizontal in water without floating.

K426 LEVEL REGULATORS to have three contacts for starting or stopping pump. One to be for pump stop at low sump level, one for start at high sump level and one for high level alarm installed above pump start regulator.

K430 CONTROL PANEL: totally enclosed, wall mounted, direct on line type, with no volt and overload protection in each phase, suitable for automatic operation of pump.

K435 MANUFACTURERS: obtain unit from one of the following:

| | |
|---|---|
| Flygt | (U.K.) |
| Pullen Pumps | (U.K.) |
| Ritz | (Germany) |

or approved equal.

414:L FIRE PUMPS

414:L1 MAIN FIRE PUMP

L105 TYPE: horizontal, base mounted, horizontal split case, double suction, single stage, centrifugal type directly connected to electric motor through heavy duty flexible coupling, with pump and motor mounted on common cast iron baseplate with drip rim, drain tapping, bolt holes and grouting hole.

L110 STANDARD: pump is to be listed by Underwriters' Laboratories and meet requirements of the NFPA, Pamphlet No. 20 or approved equal international association.

L115 CAPACITY AND PRESSURE to be as shown on the Drawings. Pump is to deliver not less than 150% of rated capacity at pressure not less than 65% of rated pressure. Shut-off pressure is not to exceed 120% of rated pressure.

L120 UNIT to be complete with pump, driver, controller and accessories from factory.

L125 CASING: cast iron, minimum tensile strength 241 MPa, designed for working pressure of 1720 kPa and hydrostatically tested at factory to not less than 1720 kPa.

L126 CASING: bearing housing supports and suction and discharge flanges to be integrally cast with lower half of casing. Removal of upper half of casing is to allow removal of rotating element without disconnecting suction and discharge flanges.

L130 CASING WEAR RINGS to be renewable and locked by dowelling to prevent rotation.

L135 IMPELLER to be vacuum cast bronze, enclosed type, dynamically balanced, keyed to shaft and held in place with bronze threaded shaft sleeve.

L140 SHAFT SLEEVES: to extend entire length of seal boxes to protect shaft and key locked and threaded to tighten with rotation of shaft. Teflon gaskets to be provided between impeller hub and shaft sleeves to protect pump shaft.

L145 BEARINGS: pump rotating element to be supported by two heavy duty, grease lubricated ball bearings mounted in machined moisture proof and dust proof cast iron housing and bolted to pump casing with register fits to ensure permanent alignment. Grease seals and water slingers to be provided to protect bearings from contamination. Bearing housings to be designed to flush lubricant through bearing. Easily accessible grease fittings to be provided for positive bearing lubrication.

L150 SHAFT to be high strength steel accurately machined to give true running rotating element and sealed by split packing glands designed for easy removal for inspection and maintenance.

L155 PACKING: to consist of interwoven, graphited asbestos, diagonally cut packing rings with lantern ring connected to pressure side of pump by a cored passage in parting flange of pump.

L160 ELECTRIC MOTOR: drip-proof, squirrel cage, induction type with permanently lubricated and sealed ball bearings. Motor speed is not to exceed 2900 rpm. Motor service factor is to be 1.15.

L165 ACCESSORIES: pump to be supplied complete with the following :

lifting lugs

coupling guard

tapped holes in suction and discharge flanges for pressure gauge connections

suction and discharge pressure gauges, with minimum 89 mm dial reading in kg/cm2 and having range equal to twice rated design working pressure of pump and complete with gate valves

main relief valve, size 80 mm minimum, factory set to open at pressure slightly greater than rated design working pressure of pump, with capacity to pass all water discharged by pump without developing excessive pressure on system

casing relief valve sized to prevent overheating of pump when operating at shut-off, factory set to open just higher than rated design working pressure of pump and lower than shut-off discharge pressure

automatic air release valve on casing vent.

L170 CONTROLLER: wall mounting, watertight construction, marked 'Fire Pump Controller', completely assembled, wired and tested at factory ready for installation and operation with simple external electrical connections.

L171 CONTROLLER shall be a combined manual and automatic auto-transformer starter for motors rated at 50 HP or more, or direct-on-line starters for motors rated at less than 50 HP, containing the following: externally operable disconnect switch, circuit breaker with interrupting capacity according to the maximum short circuit level at the controller location, magnetic starter, pressure switch, pilot lamp to indicate circuit breaker closed and power available, ammeter test link, voltmeter test studs and two position selector switch

marked 'automatic' and 'non- automatic'. Autotransformer starter shall be a closed transition type and suitable for 15 starts per hour repeated after 2 hours for motors up to 200 HP and 3 starts per hour repeated after one hour for motors over 200 HP. The autotransformer shall be a dry type with insulation class F and temperature rise class B above ambient temperature.

L172 CIRCUIT BREAKER of the fire pump controller to be UL listed or in compliance with IEC 60947-2, utilisation category B, sequence II (service capacity).

L173 AUTOMATIC TRANSFER SWITCH (ATS) which is dedicated for fire pumps shall meet the requirements of NFPA 20, installation of "Centrifugal Fire Pumps", NFPA 70 'National Electric Code" and shall be listed by Underwriter Laboratories Inc. (UL) including UL-1008 "Automatic Transfer Switches' and UL-508 "Industrial Control Equipment" and the electrical specifications section 213. A combined UL-listed fire pump automatic transfer switch and controller is acceptable.

L175 PERFORMANCE TEST: pump to be completely tested at factory with positive suction pressure and with a 4.5 m suction lift. Certified performance curves for both conditions to be submitted for approval prior to shipment.

L180 MANUFACTURERS: obtain unit from one of the following:

| | |
|---|---|
| ITT Bell & Gossett | (U.S.A.) |
| Aurora Pumps | (U.S.A.) |
| Peerless Pump | (U.S.A.) |
| Worthington | (U.S.A.) |

or approved equal.

414:L2 JOCKEY FIRE PUMP

L205 TYPE: close-coupled, regenerative turbine type, with in- line suction and discharge openings.

L210 CONSTRUCTION: casing to be cast iron, designed for working pressure of 2070 kPa and hydrostatically tested at this pressure at factory. Impeller to be bronze, double suction, hydraulically balanced design, dynamically balanced, keyed and bolted to stainless steel shaft.

L211 CONSTRUCTION: pump to have internal sealing water passages, removable chrome-plated cast iron channel rings, mechanical seal with carbon washer, Ni-resist face

and stainless steel parts, water slingers to protect bearings and 'O' ring gaskets to prevent leakage.

L215 ELECTRIC MOTOR to be close-coupled to pump, drip-proof, squirrel cage, induction type, with permanently lubricated and sealed ball bearings. Motor speed is not to exceed 2900 rpm.

L220 STARTER: totally enclosed, wall mounted, direct-on- line, with no-volt and overload protection in each phase and suitable for automatic operation.

L225 MANUFACTURERS: obtain pump from one of the following:

| | |
|---|---|
| Aurora Pumps | (U.S.A.) |
| Peerless Pump | (U.S.A.) |
| Worthington | (U.S.A.) |

or approved equal.

## 414:L3 EMERGENCY FIRE PUMP

L305 UNIT: to comprise diesel engine driven fire pump supplied complete as a packaged unit with engine, fuel tank, hand operated diaphragm pump for filling fuel tank, fuel pipework, automatic starting equipment and electric control panel all mounted on steel skid type base for permanent mounting with foundation bolt holes and adequate grout volume.

L310 STANDARDS: unit is to comply with the requirements of one of the following standards:

National Fire Protection Association, Pamphlet 20 (U.S.A.)

Factory Mutual (U.S.A.)

Underwriters' Laboratories (U.S.A.)

or approved equal international society.

L315 PUMP: horizontal, two-stage, centrifugal type, with flanged side suction and flanged top discharge, and directly connected to engine through heavy duty flexible coupling. Pump and engine to be perfectly aligned at factory.

L320 PUMP CASING AND COVER: close grained cast iron for 1030 kPa operating pressure. Casing to be hydrostatically tested at factory to 2070 kPa.

L325 IMPELLERS: bronze, hand finished, dynamically balanced, keyed and secured to shaft by bronze impeller nut and washer designed to prevent leakage to shaft. Impellers to be positioned back to back to eliminate end thrust.

L330 SHAFT: high tensile steel, sized for maximum stiffness and freedom from vibration.

L335 BEARINGS: shaft to be supported on two grease lubricated ball bearings, with screw down grease cups for positive bearing lubrication.

L340 IMPELLER WEAR RINGS AND SHAFT SLEEVE: pump to have lead bronze renewable impeller wear rings and cast bronze shaft sleeve extending through stuffing box to prevent shaft wear.

L345 STUFFING BOX: water sealed, with soft woven graphited packing, bronze lantern ring, gland nut and moulded rubber water slinger to protect bearings from water contamination. It is to be adjacent to first stage impeller and subjected to suction pressure only.

L350 PUMP SUPPORT: substantial cast iron driving head is to be provided to ensure rigid support for pump and bearings.

L355 ACCESSORIES: pump to have air release valve on casing, drain plugs and continuous by-pass pipe with orifice from pump discharge nozzle back to suction source to protect pump from overheating when running with closed discharge.

L360 DIESEL ENGINE to be air cooled, with adequate power to drive pump at rated speed continuously on full load at site elevation for six hours and with dry type air filter on air intake.

L365 ENGINE STARTING SYSTEM to be automatic, comprising two sets of 12 V batteries mounted on bed plate, battery powered starting motor of axial displacement type, twin starter relays, battery charging system and automatic starting control panel resiliently mounted on engine bed plate. Each set of batteries to provide ten consecutive starts of cold engine under full compression without recharging.

L370 CONTROL PANEL to be housed in dust and damp protected cabinet and fully connected and tested prior to shipment, requiring only simple external connections to main

system switch and to necessary AC supply to operate battery charging system. Control panel is to incorporate the following:

automatic ten attempt engine starting circuit initiated by signal from Main Failure Panel in electric control panel of main fire pumps

triple charging circuit capable of charging both sets of batteries simultaneously

ammeter to indicate charging current being supplied

continuously lit AC indicating light
relays and timers including connections for remote alarm system

audible warning device automatically activated if engine fails to start after ten attempts

water pressure switch fitted to pump to inhibit automatic start sequence on system start-up

low suction pressure switch fitted to pump suction to prevent unit from starting unless there is a minimum head of 0.3 m of water on pump suction and to stop unit if pump looses suction.

L375 ENGINE FUEL SYSTEM: to include the following:

fuel tank of capacity for six hours running at full load

hand operated fuel line valve lockable in the open position

sediment trap

fuel level gauge

cleaning and inspection hole on tank

hand operated fuel transfer pump for filling tank

fuel filter between fuel tank and engine pump

air bleeding valve

interconnecting fuel piping.

L380 ENGINE EXHAUST SYSTEM: to include the following:

residential type silencer

short length of flexible exhaust pipe for direct fitting to exhaust outlet

necessary lengths of steel exhaust pipe.

L385 ENGINE ACCESSORIES: engine to be complete with standard tool kit, set of spare parts, installation drawings, operating and maintenance instructions and circuit diagram.

L390 MANUFACTURERS: obtain from one of the following:

| | |
|---|---|
| Aurora Pumps | (U.S.A.) |
| Peerless Pump | (U.S.A.) |
| Worthington | (U.S.A.) |

or approved equal.

WORKMANSHIP

414:1 GENERALLY

1001 PUMP AND MOTOR BASE: align and level throughout entire length and width of base and provide shims under base for level. Secure to foundation with anchor bolts and completely grout in to provide a rigid non-deflecting support. Realign after grouting in base and connecting pipework.

1051 DRAINS FOR PACKING GLANDS AND BASE: pipe to nearest floor drain or sump.

1101 PACKING RINGS: install in alternate layers staggered 90 degrees. Tighten packing for seal whilst permitting prescribed amount of leakage for lubrication.

1151 MECHANICAL SEALS: install and align in accordance with manufacturer's recommendations.

1201 BEFORE OPERATING, ensure pump is properly lubricated, rotating element rotates freely by hand, casing is vented and full of water, direction of rotation is correct, strainer is clean and suction and discharge valves are open.

1251 OPERATION: pumps are to operate stably without pulsation, vibration, noise or cavitation throughout full capacity range.

# 419 TESTING, BALANCING AND ADJUSTING

## WORKMANSHIP

### 419:1 GENERALLY

1001 CONDUCT TESTS in the presence of and as directed by the Engineer.

1051 DO NOT cover, enclose or paint any system until tested, inspected and accepted.

### 419:2 TESTING DRAINAGE AND VENT PIPE SYSTEMS

2001 BEFORE INSTALLING SANITARY FIXTURES, subject systems to water pressure test to prove tightness and to flow test to prove freedom from obstruction.

2051 WATER PRESSURE TEST: apply to whole system or in sections. Close all openings with cast iron pipe plugs or by other approved means and fill system with water to point of overflow at highest opening. Vent all air and ensure that water reaches all parts of system to be tested. No section to be tested to less than 3 m head of water.

2101 TEST PERIOD to be for at least 4 hours prior to inspection of system. Inspect all joints and pipes whilst under pressure and correct leaks or defective joints by replacing with new joints and materials. Makeshift repairs and application of repair compound will not be permitted.

2151 REPEAT TEST after corrections are made and until systems are proven tight.

2201 OBSTRUCTIONS in systems are to be cleared and systems subjected to further test at no extra cost.

### 419:3 TESTING WATER PIPING SYSTEMS

3001 HYDROSTATICALLY TEST systems in whole or in sections to prove tightness under specified test pressure. Maintain test pressure for period specified under system concerned. All parts of systems are to be subjected to test pressure.

3051 TEST PROCEDURE: apply test before connecting piping to equipment. Remove, disconnect or blank off equipment, accessory or device which might be damaged by test pressure. Valves are to be open but not completely backseated. End valves are to be capped. On flanged piping, temporary blank flanges are to be installed and firmly anchored to accommodate developed end thrust. Piping that may be damaged by end thrust is to be properly anchored, especially at changes in direction.

3052 TEST PROCEDURE: plug and blank off openings in system and fill slowly with water. Vent entrapped air. Ensure water reaches all parts of system. Apply pressure with hand pump connected to discharge into system through a globe valve, check valve and recently calibrated pressure gauge. When test pressure is reached close globe valve and monitor pressure variations. System is not to have any noticeable drop in pressure throughout specified period that test pressure is maintained.

3053 TEST PROCEDURE: with system under pressure, inspect pipes and joints for leaks.

3101 DEFECTS: replace defective parts. Makeshift repairs and application of repair compound will not be permitted.

3151 REPEAT TEST until completely tight system is obtained.

3201 RELEASE PRESSURE slowly to prevent damage.

## 419:4 TESTING OF EQUIPMENT

4001 TEST all equipment to prove performance and proper functioning and to demonstrate to the Engineer's satisfaction that equipment meets design requirements.

4051 DATA TO BE MEASURED are those parameters given on the Schedule of Equipment.

## 419:5 TESTING AND ADJUSTING CONTROLS

5001 OPERATE CONTROLS AND INSTRUMENTS simultaneously with equipment or system controlled and test for proper, accurate and dependable operation.

5051 CALIBRATE AND ADJUST until approved.

## 419:6 TESTING PUMPS

6001 TESTS AFTER INSTALLATION: carry out the following:

test pump for flow and head against actual system friction loss and static pressure to demonstrate that pump meets specified requirements

measure pump shut-off pressure for comparison with manufacturer's performance curve

measure phase current and voltage for calculation of motor horsepower.

6051 RE-TEST after pump or equipment is adjusted, repaired or replaced.

# 42 WASTE DISPOSAL AND DRAINAGE

## 421 SANITARY DRAINAGE AND VENT SYSTEM

### 421:A GENERALLY

A105 REFER TO SECTION 41 PLUMBING - GENERAL for pipework, fittings and other products common to this and other plumbing installations.

### 421:H PIPES

H105 PIPES 50 mm diameter and under to be galvanised steel, pipes over 50 mm diameter to be cast iron soil pipe, unless otherwise specified. All underground piping to be cast iron minimum 50 mm diameter.

H110 PIPES 50 mm diameter and under to be PVC pressure pipe. Pipes over 50 mm diameter to be non-pressure PVC pipe.

H120 PVC PIPES AND FITTINGS to be product of same manufacturer.

### 421:K PUMPS

K105 REFER TO SUB-SECTION 414:K1.

### 421:K3 SUBMERSIBLE SEWAGE PUMP

K305 REFER TO SUB-SECTION 414:K3.

### 421:K4 SUBMERSIBLE SUMP PUMP

K405 REFER TO SUB-SECTION 414:K4.

### 421:X COMPONENTS AND ACCESSORIES

X115 CLEANOUTS ON UPVC PIPES: solvent weld fitted with screw cap and washer:

Man: Caradon Terrain (U.K.)
Ref: 136

or approved equal.

X120 CLEANOUT ACCESS COVERS: 178 mm x 178 mm square frame with anchor lugs and cover plate secured with screws. Frame and cover to be polished nickel bronze with smooth finish; as per:

Man: Zurn
Ref: No.Z-1460

or approved equal.

X130 FLOOR DRAINS: coated cast iron comprising drain body with integral seepage pan, clamping collar secured to drain body with screws and threaded adjustable head strainer body permitting up to 32 mm vertical adjustment of strainer height without disturbing flooring or connections during installation.

X131 PVC FLOOR DRAINS: combine floor drain and integral trap seal shall have 3 number 50 mm auxiliary side inlets and 75 mm side outlet, adjustable strainer permitting vertical adjustment of strainer height without disturbing flooring or connection during installation, as manufactured by Nicoll No SEMX20, or equal. Strainer body shall permit installation of different interchangeable strainer variation, and when needed, to fit into adjustable PVC extension collar, Nicoll No ZXSIT or equal. Access to the trap seal shall be made possible through a 12.5 mm diameter opening fitted with a plastic cleanout plug. TYPE FD-1 shall have a round flat strainer as manufactured by Nicoll or approved equal.

X132 FLOOR DRAINS: strainer body is to permit installation of different interchangeable strainer variations on same floor drain. Floor drains to have inside caulked bottom outlet with adjusting screws.

X133 FLOOR DRAINS: strainer to be nickel bronze secured to strainer body with vandal-proof brass screws.

X141 FLOOR DRAINS TYPE FD-1: to have 150 mm round flat strainer with 58 sq.cm. minimum open free area; as per:

Man: Zurn

Ref: No. Z-415

or approved equal.

X142 FLOOR DRAINS TYPE FD-2: to have 150 mm round strainer with 178 mm round nickel bronze detachable funnel; as per:

Man: Zurn
Ref: No. Z-415, Z-414

or approved equal.

X150 VENT COWLS: galvanised wire basket to fit snugly inside open end of vent pipes extending above roof.

X160 DRIP PANS: provide under piping where impossible to route water or drainage piping passing over or within 1.5 m of electrical apparatus and in rooms containing electrical equipment.

X161 DRIP PANS: 1.3 mm thick galvanised sheet metal, reinforced and made water tight.

## WORKMANSHIP

### 421:1 GENERALLY

1001 REFER TO SECTION 41 PLUMBING - GENERAL for workmanship common to this and other plumbing installations.

1051 EXECUTE workmanship in accordance with the American Standard National Plumbing Code or approved equal standard.

### 421:2 PIPEWORK

2001 HORIZONTAL PIPES: lay at uniform slope of not less than 1% and not more than 3%.

2051 CHANGES OF DIRECTION in pipes are to be gradual using long sweep fittings and 45 degree fittings.

2052 CHANGES OF DIRECTION: avoid unnecessary turns and offsets and run wastes as direct as possible from sanitary fixtures to vertical stacks.

2101 VENT SANITARY FIXTURES to prevent siphonage of traps and air binding.

2151 VENT PIPES: slope and connect to drip back into soil or waste pipe by gravity.

2152 VENT PIPES: where connected to a horizontal soil or waste pipe connect vent pipe above centreline of soil or waste pipe. Vent pipe is to rise vertically or at an angle of not more than 45 degrees from vertical to a point at least 150 mm above flood level rim of fixture before offsetting horizontally or before connecting to branch vent.

2153 VENT PIPES: make connections to vent stack at least 150 mm above flood level rim of highest fixture served by vent.

2154 VENT PIPES above roof are to pass through flashed and waterproofed sleeves.

2301 CLEANOUTS ON DRAIN PIPES: provide where shown on the Drawings, at or near the foot of every vertical stack and on long horizontal pipe runs at 15 m intervals.

2601 FLOOR DRAINS: provide different types and sizes as detailed.

2665 VENT COWLS: provide on all external vent pipes.

2701 PROTECTION: keep pipes clean until final acceptance of work. Close exposed ends of incompleted lines with wooden plugs and adequately secure when pipe laying is not in progress.

421:3 PUMPS

3001 REFER TO SECTION 414 for specification of workmanship.

4241 MANHOLE is to give access to all chambers of trap.

4251 MANHOLE COVERS: to be gas tight, cast iron construction, to withstand traffic weight over trap and to fit frames. Replace if found to rattle under traffic. Plugging, barring in or filling to obtain tight covers will not be allowed.

4261 FIXING MANHOLE COVERS: recess in concrete is to be neatly and accurately made to dimensions of frame. Thoroughly embed frame in mortar and set frame and cover and to proper grade.

421:43

421:9 TESTS

9001 TEST the system as specified in SECTION 41 PLUMBING - GENERAL.

# 422 RAINWATER DRAINAGE

## PRODUCTS

### 422:A GENERALLY

A105 REFER TO SECTION 41 PLUMBING - GENERAL for pipework, fittings and other products common to this and other plumbing installations.

### 422:H PIPES

H105 PIPES: cast iron soil pipes, unless otherwise specified.

H110 PIPES 50 mm diameter and under to be PVC pressure pipe. Pipes above 50 mm diameter to be non pressure PVC pipe.

H115 PIPES AND FITTINGS to be product of same manufacturer.

### 422:K PUMPS

### 422:X COMPONENTS AND ACCESSORIES

### 422:X1 SUNDRIES

X105 CLEANOUTS: as specified in Section 421 - Sanitary Drainage and Vent System.

X111 ROOF DRAIN TYPE RD-1: uPVC, elevated dome type, suitable for flat roof finish; and supplied complete with removable dome grid, screws and washers. Drain to be smooth and screw fixed to roof slab; as per:

Man: Caradon Terrain (U.K.)
Ref: model No. 2171

or approved equal.

## WORKMANSHIP

## 422:1 GENERALLY

1001 REFER TO SECTION 41 PLUMBING - GENERAL for workmanship common to this and other installations.

1051 EXECUTE workmanship generally as specified in Section 421 Sanitary Drainage and Vent System, unless otherwise specified.

## 422:2 PIPEWORK

2001 HORIZONTAL PIPES: install at uniform slope of not less than 1%.

2011 CONNECTION TO ROOF DRAIN: use expansion joint or pipe offset.

2021 INSULATE rainwater offsets and bodies of roof drains to prevent formation of condensate.

2051 CHANGES IN DIRECTION: make with long radius fittings.

2101 CLEANOUTS: provide at changes of direction, at base of vertical stacks and at maximum 15 m intervals on straight runs.

2105 ROOF DRAINS: install in a completely watertight manner with the roof as detailed on the Drawings.

## 422:3 PUMPS

3001 REFER TO SECTION 414 for specification of workmanship.

## 422:9 TESTS

9001 TEST the system as specified in SECTION 41 PLUMBING - GENERAL.

# 424 PLUMBING FIXTURES

## PRODUCTS

### 424:A GENERALLY

A105 REFER TO SECTION 41 PLUMBING-GENERAL for pipework, fittings and other products common to this and other plumbing installations.

### 424:X COMPONENTS AND ACCESSORIES

#### 424:X1 GENERAL

X105 PLUMBING FIXTURES, trim and accessories to be obtained from one approved manufacturer unless otherwise specified.

X110 VITREOUS CHINA: first quality, of specified colour, with smooth glazed surfaces free from warps, cracks, checks, flaws, discoloration or other imperfections.

X115 VITREOUS CHINA ACCESSORIES: to match fixtures and of same manufacture and colour.

X120 EXPOSED PIPING AND METAL TRIM: chrome plated brass with polished finish guaranteed not to strip or peel off.

X125 SUBMIT FOR APPROVAL list of all proposed plumbing fixtures, trim and accessories, indicating manufacturer, type and model number and submit catalogues.

X130 SUBMIT SAMPLES of fixtures, trim and accessories for approval.

X135 STORE plumbing fixtures under cover and keep dry. Separate with clean dust sheets or polythene when not in manufacturer's own packing.

X136 STORE metal fixtures on level surface to prevent twisting. Prevent contact with cement and lime and do not pack in straw.

X140 URINAL SAFES: lead sheet to BS EN 12588.

X145 SELF TAPPING SCREWS: to BS 4174.

X150 MORTAR: to comprise cement and sand (1:1) or (1:2).

X155 BLACK BITUMEN COATING SOLUTION for cold application to BS 3416.

X160 LEAD CAULKING COMPOUND: equal parts of red and white lead mixed with hempen spun yarn and mixed to a stiff consistency.

X165 WATERPROOF JOINTING COMPOUND FOR WASTES: type recommended by waste manufacturer.

## 424:X2 LAVATORIES

X210 LAVATORY - TYPE LAV-1: white vitreous china, 555 x 405 mm, countertop type, with one hole in center for cold and hot water single mixer and with overflow, Twyfords ARIA WB 2050 WH, or approved equal; complete with the following trim and accessories or approved equal:

mixer, with 32 mm pop-up waste, Grohe No. 21610, and two handles with blue/red indices, Grohe No. 18956 with fastening set

32 mm chrome plated bottle trap with adjustable inlet pipe, wall tube and wall flange, Grohe No. 28920

15 mm angle valve with 300 mm long chrome plated copper tube, blue index, Grohe No. 22960

15 mm angle valve with 300 mm long chrome plated copper tube, red index, Grohe No. 22960

## 424:X3 BIDET

X305 BIDET – TYPE BD-1 (white, coloured) vitreous china, with one hole in centre for cold and hot water single mixer and with overflow, j (floor mounted Ideal Standard model Verdi Ref. R3735, wall mounted with support frame Ideal Standard model Verdi Ref. R3739, or approved equal; complete with the following trim and accessories, or approved equal:

mixer, with 32 mm pop-up waste, Grohe No. 24610, and two handles with blue/red indices, Grohe No. 18956 with fastening set

32 mm chrome plated p-trap with adjustable inlet pipe, wall tube and wall flange, Grohe No. 28946

15 mm angle valve with 300 mm long chrome plated copper tube, blue index, Grohe No. 22960

15 mm angle valve with 300 mm long chrome plated copper tube, red index, Grohe No. 22960

crystal soap dish, Grohe No. 40046 with chrome plated holder

## 424:X4 WATER CLOSETS

X405 WATER CLOSET - TYPE EWC-1: (white, coloured), vitreous china, floor mounted, S-trap bottom connection, close coupled to flush tank, Ideal Standard model Verdi Ref. R3436, or approved equal; complete with the following trim and accessories, or approved equal:

6 litre cistern with chrome plated push botton and valve fittings including side inlet, dual flush and overflow, Ideal Standard Ref. R3640

solid plastic seat and cover of same colour as water closet with stainless steel hinges, rubber washers and plastic screws and nuts, Ideal Standard Ref. R3936

15 mm angle valve with 300 mm long chrome plated copper tube, blue index, Grohe No. 22960

toilet paper holder, chrome plated, Grohe No. 40053

## 424:X5 URINALS

X510 URINAL - TYPE UR-1: (white, coloured), vitreous china wash out urinal, wall mounted, Twyfords CAMDEN No. VC 7003, or approved equal; complete with the following fittings and accessories, or approved equal:

32 mm chrome plated bottle trap with wall flange, Twyfords No. WF 8463 CP and WF 8467 CP

j (white, coloured), vitreous china automatic type flush tank and fittings, wall hung, complete with plastic syphon drip tray with capacity of:

j (4.5 litres (single bowl) Twyfords No. CX 8611 WH, or approved equal; 9 litres (2/3 bowls) Twyfords No. CX 8612 WH, or approved equal; 14 litres (4/5 bowls) Twyfords No. CX 8613 WH, or approved equal )

flush tank to be complete with the following Twyfords trim and accessories or approved equal:

j (concealed, exposed chrome plated) copper flush pipes, complete with spreaders, tees, elbows and clips.

wall hangers, Twyfords No. SR 5706 XX

stainless dome outlet grating 32 mm, Twyfords No. WF 9370 XX

424:X7 SHOWER

X705 SHOWER - TYPE SH-1: (white, coloured), vitreous china, 800 x 800 x 150 mm deep, with anti-skid floor and 50 mm drain opening, Ideal Standard mode Verdi Ref. R3028, or approved equal; complete with the following trim and accessories, or approved equal:

chrome plated bath mixer with ceramic headparts, automatic rocker switch: bath/shower, 15 mm shower outlet, integrated non-return valve, Grohe No. 25610 with handles Grohe No. 18956 with fastening set

chrome plated shower rail, 600 mm with wall brackets, sliding piece and swivel holder, Grohe No. 28666

chrome plated handshower, Grohe No. 28172

shower hose 1750 mm, Grohe No. 28154

soap tray, Grohe No. 28856

chrome plated basket sponge holder

waste and overflow with 40 mm waste fitting with strainer, 32 mm overflow fitting with plug and chain, 40 x 50 mm trap with threaded outlet and plastic overflow pipe

chrome plated robe hook, Grohe No. 40052

424:X8 SINKS

X805 KITCHEN SINK- TYPE KS-1: stainless steel type 316, inset type for fixing into counter top, double bowl, single drainer, 18 guage thickness, with 2 faucet holes. Sink to be self rim as manufactured by FRANKE CL 621, or approved equal; complete with the following trim and accessories as manufactured by Grohe, or approved equal:

two 50 mm sink wastes with stainless steel gratings

two 50 x 50 x 40 mm outlet pipes

40 x 40 mm bottle p- trap with extension pipe and flange

40 mm round nuts

washerless ceramic disc valve

swing lever mixer with pull-out spray and ceramic disc cartridge

15 mm single handle gooseneck faucet for potable water

two stainless steel detachable overflows

X835 MOP SINK - TYPE MS-1: white vitreous china, 465 x 410 mm, 200 mm deep, wall hung with supporting legs, bucket grating and hardwood rim, Twyfords No. FC 1033 WH, or approved equal; complete with the following trim and accessories, or approved equal:

15 mm tap, Twyfords No. SF 5204 CP

40 mm grid waste, Twyfords No. WF 4343 CP

stainless steel hinged bucket grating

supporting legs, 300 mm high, Twyfords No. SR 3048 XX

two built-in cantilever brackets Twyfords No. SR 1331 XX

40 mm plastic P-trap, Twyfords No. SR 8493 XX.

## 424:X9 MISCELLANEOUS FIXTURES AND FITTINGS

X925 WATER COOLER - TYPE WC-1: refrigerated, self-contained, floor-mounted type, with cooling capacity of 26.5 litres per hour from 27 deg. C inlet water to 10 deg. C drinking water in a room ambient temperature of 32 deg. C when operating on 50-cycle electric current. Water cooler to have stainless steel top finished to reduce stains, scratches and finger marks and removable drain strainer to permit cleaning of drain pipe or precooler without removing top. Cooler body to have grey baked enamel finish. Water cooler to have anti- squirt, anti-hose bubbler with built-in strainer and pressure regulator to deliver

smooth even flow at supply pressures of 140 to 830 kPa. Refrigeration system to be hermetically sealed and to have molecular sieve. Freon - 12 refrigerant flow to be controlled by capillary tube. Water temperature to be controlled by adjustable thermostat. Supply specifically for available current characteristics complete with 3-wire grounding cord and plug. Obtain from one of the following:

| | |
|---|---|
| Elkay | (U.S.A.) |
| Filtrine | (U.S.A.) |
| Haws | (U.S.A.) |

or approved equal.

X960. WATER TAP - TYPE WT: 15 mm, chrome plated brass, back inlet connection, similar to Grohe No 30066, or approved equal.

X970 HOSE BIBB - TYPE HB: to consist of chrome plated metal bibcock, 15 mm male back inlet connection and 15 mm male, hose thread outlet, with 15 mm chrome plated metal hose union female threaded similar to Grohe No. 30086, or approved equal.

X980 BIBCOCK WITH PERINEAL HOSE – TYPE BPH: bibcock to be 15 mm, chrome plated, wall mounted with threads outlet, Grohe No. 28359, or approved equal; complete with the following accessories, or approved equal:

15 mm angle valve, blue index, Grohe No. 22958

chrome plated metal flexible tube, 1250 mm long with 15 mm nut, nozzle and loop, Grohe No. 28102

chrome plated wall hook, Grohe No. 28605

X990 LIQUID SOAP DISPENSER TYPE SD-1: surface mounted with concealed fixing wall plate. Hood to be stainless steel 304 with polished finish. Container to be translucent plastic with visible liquid level. To be as manufactured by:

Bobrick

or approved equal.

X993 PAPER TOWEL DISPENSER TYPE PTD-1: surface mounted, stainless steel with satin-finish. Door to be equipped with full-length stainless steel piano hinge and tumbler lock. Cabinet slots to indicate refill time. To be similar to:

Man: Bobrick

Ref: model B-262

or approved equal.

WORKMANSHIP

424:1 GENERALLY

1001 REFER TO SECTION 41 PLUMBING - GENERAL for workmanship common to this and other plumbing installations.

424:2 FIXING

2001 PROTECTION: retain protective coverings, when practical, during and after fixing. Do not stand in or on any fixture. Do not use fixtures for preparing or soaking materials or for washing tools. Replace fixtures which are chipped or scratched.

2051 FIX plumbing fixtures in accordance with manufacturer's recommendations. Use fastenings supplied by manufacturer wherever possible.

2052 FIX plumbing fixtures straight, true and securely to supporting surfaces. Lay out roughing where required to accurately conform with finished walls and floors.

2151 FLOOR FIXING: do not bed floor standing fixtures in cement mortar unless so specified.

2201 CORBELLED FIXTURES: rigidly support built-in and cast- in fixtures until wall is complete.

2202 CORBELLED FIXTURES: do not fix to chair supports until wall finishes are complete.

2251 SHOWER TRAYS: bed to concrete substrates on continuous layer of cement-sand mortar 1:5.

2301 CISTERNS: fix at height recommended by manufacturer unless otherwise specified or detailed.

2351 POINTING: seal joints between fixtures and adjacent surfaces with synthetic rubber based sealant in accordance with manufacturer's instructions.

2401 COVER TRIM: seal joints between fixtures and adjacent surfaces with plastics cover trim fixed with adhesive recommended by manufacturer, mitre all corners and remove surplus adhesive.

## 424:3 PROTECTION

3001 CHROME PLATED TRIM: use strap or padded wrenches when fixing.

3002 CHROME PLATED TRIM: apply ample coating of petroleum jelly on exposed surfaces immediately after installation for protection until final acceptance.

## 424:4 CONNECTING TO PIPES

4001 CONNECT fixtures to drain and water supply pipes in an approved gas-tight and watertight manner.

4011 TAPS: fix in accordance with manufacturer's recommendations making watertight seal with fixture and backnut.

4051 WASTES: bed in waterproof jointing compound and fix with resilient washer between fixture and backnut.

## 424:5 FIXING SLAB AND STALL FIRECLAY URINALS

5001 LEAD SAFES: construct with lead burned joints. Apply one coat cold bitumen to surfaces which will be in contact with mortar or grout.

5051 SETTING OUT: assemble ranges dry to check fit and accuracy. Inform the Engineer if unsatisfactory.

5101 OUTLET CHANNELS: bed to waste connector with bedding compound.

5151 SLABS: completely fill space behind with cement sand grout 1:5.

5201 JOINTS to be not wider than 3 mm. Rake out to depth of 6 mm and point flush with jointing compound supplied by urinal manufacturer.

5251 TREADS: bed in cement-sand mortar 1:5, with fall towards channel.

## 424:6 CLEANING AND PAINTING

6001 CLEAN off labels, plaster, paint droppings, petroleum jelly and other foreign matter from fixtures, trim and accessories, polish and test for perfect working condition before hand over.

6051 PAINT concealed brackets, hangers and plates.

# 43 LIQUIDS SUPPLY

## 431 DOMESTIC COLD WATER

PRODUCTS

### 431:A GENERALLY

A105 REFER TO SECTION 41 PLUMBING - GENERAL for pipework, fittings and other products common to this and other plumbing installations.

### 431:H PIPES

H110 PIPES: PPR Polypropelyne pipe.

H112 PIPES: ductile iron where indicated on the Drawings.

H115 WATER RESERVOIR PIPING CONNECTIONS: galvanised steel pipe with threaded ends.

### 431:J PUMPS

### 431:J1 END SUCTION CENTRIFUGAL PUMP

J105 REFER TO SUB-SECTION 414:J1.

### 431:J4 CONSTANT PRESSURE PUMPING UNIT

J405 REFER TO SUB-SECTION 414:J6.

### 431:J5 PRESSURISED WATER SUPPLY PUMPING UNIT

J505 REFER TO SUB-SECTION 414:J7.

### 431:X COMPONENTS AND ACCESSORIES

X130 WATER HAMMER ARRESTER: to consist of heavy duty balanced expansion bellows in stainless steel enclosure unit, pre-charged and permanently sealed at factory; as manufactured by:

Smith Hydrotrol

or approved equal.
X131 WATER HAMMER ARRESTER: where concealed, to be made accessible by means of access doors or removable panels.

## 431:X3 POLYETHYLENE (PE) WATER TANK

X305 TANK: PE water tanks to be of dimensions or volume as indicated on the Drawings. Material and manufacturing technique to FDA approval.

X310 CONNECTIONS: tank to be provided with the necessary piping connections for water inlet, water outlet, vent, overflow, drain and as shown on Drawings and of sizes indicated. All piping connections to the tank to be of polyethylene, female threaded, half couplings.

X315 RESISTANT: tank to be hygienic, hermetically sealed with weather resistant, and resistance to UV lights, stress, cracking and corrosion.

X320 ACCESS: tank to be provided at its top with access opening enabling to reach water inlet connection and float valve. The access opening to be provided with a tight cover.

X325 BASE: tank to be mounted on 100 mm thick concrete base.

## WORKMANSHIP

## 431:1 GENERALLY

1001 REFER TO SECTION 41 PLUMBING - GENERAL for workmanship common to this and other plumbing installations.

## 431:2 UNDERGROUND PIPEWORK

2001 INSTALL at least 3 m away from any sewer line. Protect from contamination from any source.

2051 GALVANISED STEEL PIPES: protect by wrapping with tape wound spirally and firmly around pipe with adequate overlap. Pay particular attention to protection at threaded joints.

## 431:3 WATER RESERVOIR PIPEWORK

3001 PIPE CONNECTIONS into walls of water reservoirs and tanks are to be installed at time concrete is poured. Locate correctly and take precautions to prevent dislocation and entry of concrete. Connections are to have no-leak flanges located centrally in wall and are to project 50 mm within reservoirs and tanks and 150 mm beyond outside walls.

3051 OPEN ENDED CONNECTIONS to have galvanised steel mesh fitted in an approved manner.

3101 PIPE INLET CONNECTIONS to have inverts at least 100 mm above top of overflow pipe.

3151 VALVED CONNECTIONS to have valves immediately adjacent to reservoir or tank.

## 431:5 PUMPS

5001 REFER TO SECTION 414 for the specification of workmanship.

## 431:6 VALVE BOX

6101 CONSTRUCTION: in situ reinforced concrete, with 560 mm diameter opening in top, recessed to accommodate cast iron frame and cover, as shown on the Drawings.

6141 FLOORS AND WALLS: plaster internally with two coats cement and sand (1:3) to total thickness of 15 mm.

6151 STEPS: galvanised pipe steps set in place during construction, properly embedded, beginning 600 mm above bottom and spaced at approximately 350 mm centres.

6181 COVERS are to fit frames. Replace if found to rattle under traffic. Plugging, burning in or filling to obtain tight covers will not be allowed.

6182 COVERS: recess in concrete is to be neatly and accurately made to dimensions of frame. Thoroughly embed frame in mortar and set frame and cover level and to proper grade.

431:9 TESTS

9001 HYDROSTATICALLY TEST system as specified in Section 41 Plumbing - General to a pressure of 1030 kPa applied for 24 hours.

# 432 DOMESTIC HOT WATER

## PRODUCTS

### 432:A GENERALLY

A105 REFER TO SECTION 41 PLUMBING - GENERAL for pipework, fittings and other products common to this and other plumbing installations.

### 432:H PIPES

H105 PIPES: PPR.

### 432:J PUMPS

### 432:J1 CIRCULATING PUMP (WET - MOTOR)

J105 REFER TO SUB-SECTION 414:J4.

### 432:J2 CIRCULATING PUMP (DRY - MOTOR)

J205 REFER TO SUB-SECTION 414:J5.

### 432:P INSULATION

P105 PIPE INSULATION: 25 mm thick, preformed, rigid, sectional, fibreglass pipe insulation, average thermal conductivity not exceeding 0.033 W/m deg. C at mean temperature of 24 deg. C and minimum density of 80 kg/m3.

P106 FLEXIBLE ELASTOMERIC THERMAL INSULATION: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials. Insulation to conform to NFPA 90A and NFPA 90B requirements.

1. Adhesive: Solvent base, contact adhesive, as recommended by insulation material manufacturer.

2. Ultraviolet-Protective Coating: As recommended by insulation manufacturer.
3. Thermal Conductivity: ≤ 0.038 W/mK at 20 deg. C (68 deg. F).
4. Density: 65 to 80 kg/$m^3$.
5. Water Vapor Permeability: 0.15 perm-inch.
6. Insulation thickness: 19mm for pipes 50mm and smaller; 25mm for pipes larger than 50mm.
7. Noise Reduction up to 27 ΔL for 20 mm thick insulation.

P150 INSULATION FOR VALVES AND FITTINGS: fibreglass blanket, minimum density 16 kg/m3.

P205 MANUFACTURERS: obtain insulation from one of the following:

| | |
|---|---|
| ISOVER Saint Gobain | (France) |
| Johns-Manville | (U.S.A.) |
| Owens-Corning Fiberglas | (U.S.A.) |

or approved equal.

P210 WATERPROOFING: 6.8 kg asphalt-impregnated roofing felt.

P215 INSULATION SHIELDS: galvanised sheet metal 1 mm thick and 300 mm long.

P220 ALUMINUM JACKETING: aluminum alloy complying with ASTM B 209M. Metal thickness to be 0.6 mm on insulated pipes up to 50 mm diameter, 0.8 mm on insulated pipes up to 400 mm diameter and 1.0 mm on insulated pipes over 400mm diameter. Aluminum jacketing to be field applied to all exposed insulated pipes.

## 432:X COMPONENTS AND ACCESSORIES

### 432:X1 VALVES

X105 BACKFLOW PREVENTION VALVES: horizontal swing check type.

X110 BALANCING VALVES: globe type.

X115 AIR VENTS: automatic or manual type. Manual air vents to be globe valve type.

X130 WATER HAMMER ARRESTER: to consist of heavy duty balanced expansion bellows in stainless steel enclosure unit, pre-charged and permanently sealed at factory; as manufactured by:

Smith Hydrotrol

or approved equal.

X131 WATER HAMMER ARRESTER: where concealed, to be made accessible by means of access doors or removable panels.

## 432:X2 ELECTRIC WATER HEATER - TYPE EWH-1
(American Specifications)

X205 HEATER: cylindrical, storage type, comprising inner tank, outer jacket, immersion type electric heating elements, thermostat, electric control box, pressure and temperature relief valve, water connections, sturdy floor mounting legs or wall brackets suitable for type of heater used and magnesium anode rod to protect against electrolytic corrosion.

X210 INNER TANK: heavy gauge submerged-arc electric welded steel, designed for working pressure of 1030 kPa and hydrostatically tested to 2070 kPa at factory. Tank to be glass lined with vitreous porcelain enamel tank liner and to have stainless steel cold water dip tube to carry incoming cold water to tank bottom, anti-siphoning opening at top, 20 mm drain connection with 20 mm drain valve at bottom, 20 mm relief valve connection at top and water inlet and outlet connections.

X215 OUTER JACKET: heavy gauge steel, with two coats of anti- rust paint inside and outside and finished with durable baked-on high gloss enamel. Space between tank and jacket to be filled with blanket type glass fibre insulation of adequate thickness.

X220 COMBINATION TEMPERATURE AND PRESSURE RELIEF VALVE: size 20 mm, fitted at factory, self-closing, lever-operated type, with thermo-bulb extension, factory set at 860 kPa and 99 deg. C and directly immersed in water.

X225 HEATING ELEMENTS: immersion type, at least two in number, fitted into tank with forged steel adaptors and to be removable without draining tank. Each element to have separate contactor and high limit temperature control and to be controlled by one adjustable immersion type thermostat with range of adjustment not less than 32 to 88 deg. C.

X230 ELECTRIC CONTROL BOX to be mounted on heater at factory, to contain contactors, thermostat, necessary transformer and junction block and to be fully wired and tested at factory ready for installation with simple connection to power supply.

X235 MANUFACTURERS: obtain heater from one of the following:

| | |
|---|---|
| Rheem | (U.S.A.) |
| Ruud | (U.S.A.) |

or approved equal.

## WORKMANSHIP

### 432:1 GENERALLY

1001 REFER TO SECTION 41 PLUMBING - GENERAL for workmanship common to this and other plumbing installations.

### 432:2 PIPEWORK

2001 AIR VENTS: provide at all high points of system.

2051 EXPANSION LOOPS: provide on straight runs longer than 30 m. Provide pipe anchors and guides to control expansion of pipes as required.

### 432:3 PUMPS

3001 REFER TO SECTION 414 for specification of workmanship.

### 432:4 INSULATION

4001 DO NOT APPLY insulation until piping has been tested, approved and accepted.

4051 EXECUTION to be by skilled workmen regularly engaged in this type of work.

4101 CLEAN pipes and fittings of paint, scale, oil, grease and foreign matter before applying insulation. Apply only to dry surfaces.

4151 PIPES: insulate supply and return pipes. Insulation to be continuous through sleeves, hangers and supports.

4201 FITTINGS, VALVES AND FLANGES: firmly wrap with fibreglass blanket under compression in minimum ratio of 2:1 to obtain thickness equal to adjoining pipe insulation and tie with galvanised annealed steel wire.

4251 OVERWRAP insulation exposed to view with muslin jacket neatly lapped and pasted on with special adhesive. Use Kraft paper where necessary to provide smooth surface for installation of muslin jacket.

4301 WATERPROOF insulation on concealed pipes and on pipes installed underground or outdoors by wrapping with two layers of roofing felt, wired in place and well mopped with approved air-setting asphalt compound between each layer and finish with thick layer of same compound on outside.

4305 ALUMINIUM JACKETING: to be applied to all exposed insulated pipes, in machine rooms and outdoor applications. Fabrication details to be in accordance with SMACNA recommendations for circular ducts, and to the approval of the Engineer.

4351 PROTECT insulation passing through hangers and supports with insulation shields.

## 432:9 TEST AND BALANCE

9001 HYDROSTATICALLY TEST all supply and return piping as specified in Section 41 Plumbing - General to pressure of 1030 kPa applied for 24 hours.

9151 BALANCE: after putting into operation, completely balance the system by correctly setting all balancing globe valves on return pipes to give adequate quantity of hot water flowing in different circuits to obtain immediate hot water flow from each hot water tap in system. After balancing remove handles of balancing globe valves.

9201 OBSTRUCTIONS are to be cleared and the system subjected to a further pressure test, at no extra cost.

# 45 MISCELLANEOUS SYSTEMS

## 451 FIRE FIGHTING SYSTEM

### PRODUCTS

### 451:A GENERALLY

A105 REFER TO SECTION 41 PLUMBING - GENERAL for pipework, fittings and other products common to this and other plumbing installations.

### 451:X WATER FIRE PROTECTION SYSTEM

#### 45l:X1 PIPES AND FITTINGS

X105 PIPES: black seamless steel.

X110 FITTINGS on pipes 50 mm diameter and under to be threaded black malleable iron and on pipes over 50 mm diameter to be black seamless welding type.

X115 FLUSH AND TEST CONNECTIONS to be not less than 25 mm, with gate valve and hose adaptor.

#### 451:X2 PUMPS

X205 MAIN FIRE PUMP: refer to Sub-Section 414:L1.

X210 JOCKEY FIRE PUMP: refer to Sub-Section 414:L2.

X215 EMERGENCY FIRE PUMP: refer to Sub-Section 414:L3

## 451:X3 VALVES

X305 VALVES: rising stem type, 1210 kPa working pressure, otherwise conforming to Section 41 Plumbing - General.

X310 ALARM CHECK VALVE: constructed and equipped to give clear positive audible alarm at water flow equal to or greater than from single sprinkler, suitable for vertical installation and for variable pressure water supply.

X311 ALARM CHECK VALVE to be flanged, designed for 1210 kPa working pressure, with cast iron body and clapper hinge, bronze clapper assembly, pilot valve assembly and other moving parts.

X312 ALARM CHECK VALVE: to be complete with retarding chamber, 50 mm angle main drain valve, upstream and downstream pressure gauges with gauge cocks, alarm control and test valves, pressure operated alarm switch to actuate bell, horn or siren or perform other electrical functions and set to operate at 28 to 48 kPa water pressure, with alarm drain and check valve and all interconnecting galvanised steel piping.

X315 ALARM CHECK VALVES: 1200-kPa working pressure; designed for horizontal or vertical installation, with cast-iron flanged inlet and outlet, bronze grooved seat with O-ring seals, and single-hinge pin and latch design. Include trim sets for bypass, drain, electric sprinkler alarm switch, pressure gages, retarding chamber, and fill-line attachment with strainer.

1. Option: Grooved-end connections for use with keyed couplings.
2. Drip Cup Assembly: Pipe drain without valves, and separate from main drain piping.
3. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

X335 PRESSURE-REGULATING VALVES: 2760-kPa minimum rating, brass. Include DN40 or DN65, female NPS inlet and outlet; adjustable setting feature; and straight or 90-degree angle pattern design as indicated.

1. Finish: Rough chrome-plated.

X340 BALL DRIP VALVES: automatic drain valve, DN20, ball check device with threaded ends.

## 451:X4 WATER FLOW ALARM DEVICES

X405 TYPE: electrical switching device actuated by vane extended inside water pipe so that water flowing in pipe closes circuit and rings an alarm gong. Unit to be complete with retard or time delay to prevent false alarms. Alarm gong to be remote type, complete with all necessary appurtenances to operate with multiple water flow alarm devices.

X410 MANUFACTURER: obtain from the following:

Grinell Corporation (Holland)

or approved equal.

451:X5 AUTOMATIC SPRINKLERS

X520 AUTOMATIC SPRINKLERS TYPE SP-2: for exposed installations, pendent type of high quality bronze construction. Sprinklers to have 25 mm male thread inlet and standard 15 mm orifice with rated capacity 5 l/s at 551 kPa pressure at sprinkler.

X621 FIRE HOSE REEL: recessed, swinging type, consisting of hose reeled on hose drum mounted on inside of die-cast aluminium square door with 'FIRE HOSE REEL' decal, with stainless steel handle fitted and reel able to swing through 180 degrees. Finished recess depth not to exceed 250 mm, and supplied from factory with the following contained equipment:

one automatic valve consisting of non-rotatable outer cylinder and inner cylinder which revolves with hose drum; inside of inner cylinder to be screwed to take non-rotatable valve plunger assembly; unreeling of hose for about 2 metres is to cause valve to withdraw from its seat and allowing water to flow

one 30 m long, red rubber, 19 mm bore, smooth cover hose with working pressure of 350 kPa

one lever operated control nozzle

one 25 mm BSP male connection

one fixing plate to wall.

Man: Thorn Security-Norsen (U.K.)
Ref: Type SC

or approved equal.

X625 FIRE HOSE REEL: surface mounted, automatic swinging type fire hose reel, consisting of hose reeled on hose drum and able to swing through 180 degrees. Reel to be to BS EN 671-1 and supplied from factory with the following contained equipment:

one automatic valve consisting of non-rotatable outer cylinder and inner cylinder which revolves with hose drum; inside of inner cylinder to be screwed to take non-rotatable valve plunger assembly; unreeling of hose for about 2 m is to cause valve to withdraw from its seat and allowing water to flow

one j (18 m, 24 m, 30 m, 36 m), red rubber braided to BS 3169 Type A, j (19 mm, 25 mm) bore, smooth cover hose with working pressure of 350 kPa

one lever operated jet control nozzle

one j (19 mm, 25 mm) BSP male connection.

Man: Thorn Security-Norsen (U.K.)
Ref: Type S

or approved equal.

X635 FIRE HOSE REEL AND EXTINGUISHER CABINET: to BS EN 671-1, recessed, automatic, swinging type, flush fitting, j (vertical, horizontal) cabinet with swinging fire hose reel compartment and extinguisher compartment. Hose reeled on hose drum mounted on the inside of cabinet door. Reel to be able to swing through 180 degrees. Cabinet to be mild steel, finished with white enamel internally, complete with stainless steel architrave and recessed finger plate with "FIRE HOSE" decal for the hose reel compartment and "EXTINGUISHER" decal for the extinguisher compartment. Unit to be as manufactured by Thorn Security-Norsen (U.K.), type CF or approved equal. Cabinet to be supplied from factory with the following contained equipment:

one automatic valve consisting of non-rotatable outer cylinder and inner cylinder which revolves with hose drum; inside of inner cylinder to be screwed to take non-rotatable valve plunger assembly; unreeling of hose for about 2m is to cause valve to withdraw from its seat and allowing water to flow

one j (18 m, 24 m, 30 m, 36 m), red rubber braided to BS 3169 Type A, j (19 mm, 25 mm) bore, smooth cover hose with working pressure of 350 kPa

one lever operated jet control nozzle

one j (19 mm, 25 mm) BSP male connection

one 4.5 kg ABC nitrogen operated dry chemical fire extinguisher, with steel body and red enamel finish, complete with hose.

Man: Thorn Security-Norsen (U.K.)

Ref: Type CF

or approved equal.

## 451:X9 PIPE HANGERS AND SUPPORTS

X905 HANGERS: universal loop type, with adjustable rods and washer type ceiling plates. Thickness and width of flat steel and size of hanger rods to be as follows:

| Pipe Size mm | Dimensions of Flat Steel mm x mm | Size of Rod mm |
|---|---|---|
| 25 - 50 | 1.6 x 15.9 | 9.5 |
| 65 - 80 | 2.4 x 19.1 | 12.7 |
| 100 - 125 | 3.2 x 19.1 | 15.9 |
| 150 | 3.2 x 25 | 19.1 |

X910 SUPPORTS for vertical pipes to be clamps, bolted around pipe and with legs on both sides resting on concrete floor.

X915 EXPANSION BOLTS to be size to suit size of hanger rod.

## 451:Z MISCELLANEOUS FIRE FIGHTING EQUIPMENT

## 451:Z1 PORTABLE FIRE EXTINGUISHERS

Z105 PORTABLE FIRE EXTINGUISHERS: rechargeable type, complete with operating charge and wall mounting brackets.

Z110 PORTABLE FIRE EXTINGUISHER TYPE FE-1: 5kg ABC nitrogen operated dry chemical type, with steel body and red enamel finish, all-brass operating valve, large operating lever, full vision pressure gauge and discharge hose.

Z115 PORTABLE FIRE EXTINGUISHER TYPE FE-2: 5 kg carbon dioxide type, with steel body and red enamel finish, pull-pin, squeeze-handle, double braided hose and non-conducting discharge horn.

Z125 MANUFACTURERS: obtain portable fire extinguishers from one of the following:

| | |
|---|---|
| Angus Fire | (U.K.) |
| Nu-Swift International | (U.K.) |
| Pyrene | (Canada) |

or approved equal.

WORKMANSHIP

451:1 GENERALLY

1001 REFER TO SECTION 41 PLUMBING - GENERAL for workmanship common to this and other plumbing installations.

1051 STANDARDS: install and test system in accordance with NFPA standards or approved equal international association.

# 49 OTHER WORK IN CONNECTION WITH PLUMBING

## 491 BUILDER'S WORK

PRODUCTS

### 491:A GENERALLY

A105 BUILDER'S WORK in connection with plumbing such as equipment bases and supports, cutting and patching of walls and slabs for passage of pipes and ducts, re-patching, fixing of pipe hangers and supports to structures, excavation and backfilling, scaffolding, rigging, hoisting, waterproofing, cleaning and painting are to be provided as specified under this Section.

A110 MATERIALS are to conform to requirements included in the applicable Division of the Specification.

### 491:X ACCESSORIES

### 491:X1 SUNDRIES

X105 PIPE SLEEVES for pipes passing through walls, floors and roof to be galvanised steel pipe, two nominal pipe sizes larger than pipe passing through for bare pipes, and of sufficient size to permit pipe insulation to pass through for insulated pipes.

X110 ESCUTCHEON PLATES to be nickel plated, split ring type, sized to match pipe that it is to conceal. Plates for pipes passing through sleeves which extend above floor surfaces to be deep recessed type to conceal sleeve.

X115 FLASHING SLEEVES: coated cast iron, caulking type, size specifically to fit pipe; as per:

Man: Josam
Ref: Z-196

or approved equal.

X120 HANGERS AND SUPPORTS FASTENERS: power driven masonry expansion bolts with steel threaded studs or internally threaded studs and couplings as required.


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WORKMANSHIP

491:1 EXCAVATION

1001 EXCAVATE AND BACKFILL as necessary, including shoring, sheet piling, bracing, pumping, restoring and protection of persons and property.

1051 TRENCHES: avoid excessive length of open trench.

1101 TRENCHES FOR UNDERGROUND PIPES to be of adequate width. Carry excavation 200 mm below pipe invert. Bed bottom of trench with clean dry sand and trim by hand to receive pipes. Dig bell hole at each joint to allow for making up joint. After pipe is tested and accepted carefully backfill with selected clean earth.

1151 BACKFILL TRENCHES in 100 mm thick layers to 600 mm above pipe and in 300 mm layers thereafter. Tamp each layer carefully and thoroughly before placing next layer. Exercise care not to damage or misalign pipes.

491:2 EQUIPMENT BASES AND SUPPORTS

2001 SHOP DRAWINGS: submit for approval showing dimensions, arrangement and size of reinforcement, and locations of anchor bolts.

2051 FOUNDATIONS FOR ROTATING AND RECIPROCATING EQUIPMENT at ground level to be carried independently to solid ground or rock and isolated from floor slab with 50 mm thick layer of cork board and mastic filler to prevent transmission of vibration.

2101 EQUIPMENT ON INTERMEDIATE FLOORS OR ROOF: mount on its support on vibration isolators. Alternatively, support is to include substantial layer of corkboard between it and structure to reduce transmission of vibration to a minimum.

2151 VIBRATION ISOLATION MOUNTS: position in accordance with weight distribution of equipment and as recommended by manufacturer of equipment or mounts. Secure embedded mounts during concreting.


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2201 ALIGN AND LEVEL EQUIPMENT on bases and supports over entire length and width and shim where necessary to facilitate levelling.

2251 CONCRETE BASES AND SUPPORTS: plaster and paint or finish as adjacent and surrounding flooring.

2252 CONCRETE BASES AND SUPPORTS to be 150 mm larger all around than equipment, of height to suit equipment and with top edge chamfered.

2301 ANCHOR BOLTS: set in oversized sleeves with washers and nuts at bottom. Bolts to project at least 6 mm above nuts when equipment is fixed to allow for shimming. Secure during concreting.

2351 SUSPENDED CRADLES AND WALL BRACKETS: test to sustain a load eight times actual operating weight of equipment supported.

## 491:3 HANGERS AND SUPPORTS

3001 FASTENERS: install in accordance with manufacturer's instructions.

3051 FASTENERS to penetrate 6 to 8 times shank diameter.

3101 EMBEDDED ATTACHMENTS: fix during concreting.

3151 TEST fasteners in ceilings and walls to sustain a load eight times operating weight of piping or equipment supported.

3201 ADDITIONAL FRAMING: provide where structure is inadequate to give suitable support. Design is to be approved.

## 491:4 PIPES PASSING THROUGH WALLS AND SLABS

4001 STRUCTURAL MEMBERS: do not cut without approval. Any approved cutting is to be done only as directed.


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4051 SLEEVES to be provided for all pipes passing through walls, floors and roofs. Locate before walls etc. are constructed and fasten securely to prevent displacement during construction. Plug ends during construction.

4052 SLEEVES are to terminate flush with finished walls and ceilings and are to project 20 mm above finished floors and 250 mm above rough concrete of roof.

4101 ESCUTCHEON PLATES to be provided for all exposed uninsulated pipes passing through walls, floors and ceilings.

## 491:5 JOINERY

5001 ACCESS DOORS: provide in false ceilings, walls or other construction to permit access to equipment, controls, etc. requiring periodic operation, inspection or maintenance.

## 491:6 WATERPROOFING

6001 OPENINGS IN EXTERNAL WALLS, ROOFS AND WALLS BELOW GROUND to be made watertight with sleeves, caulking, caulking fittings and flashings. Openings in external walls, particularly at and below ground level and in roofs to be plugged and caulked with oakum and lead between pipe and sleeve.

6051 WATERPROOFED CONSTRUCTION: method of installing work piercing waterproofed construction to be subject to review and approval by the Engineer.

6101 PIPES THROUGH ROOFS to be further waterproofed with 2 mm thick lead flashing fixed to pipe with flashing sleeve and extended under roof waterproofing membrane 300 mm all round.

## 491:7 CLEANING AND PAINTING

7001 CLEAN equipment, material, piping etc. inside and outside by effective and approved methods to remove loose mill scale, blisters, sand, plaster, paint droppings, debris, dirt, oil, grease, labels, and all foreign matter. Clean and brush work in stages as directed before painting or concealing.


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7051 SURFACES TO BE PAINTED: clean with wire brush and cleaning solution. Do not apply paint to wet or damp surface.

7101 BLACK STEEL PIPING including flanges, bolts, nuts, cast iron valves and accessories, valve wheels and all ferrous parts to be painted with two coats of zinc chromate primer whether or not they are to be insulated. When bare or exposed to view, they are to be further painted with two coats of approved oil paint.

7151 PIPING run in trenches, shafts, underground or out- doors, including flanges, bolts, nuts, valves and all ferrous parts to be painted with two coats of zinc chromate primer and two coats of heavy bituminous solution paint.

7152 PIPING: when directed by the Engineer piping in machine room is to be painted to conform to the ASME Colour Code. Alternatively stencil pipes to show service, size and direction of flow. Insulated pipes to be colour coded and stencilled over the external jacket.

7301 HANGERS AND SUPPORTS including clamps, rods, bolts, nuts etc. are to be painted with two coats of zinc chromate primer and where exposed to view with two additional coats of approved oil paint.

7351 DAMAGED SURFACES of equipment to be restored to original condition by cleaning and painting as directed.

7401 UNFINISHED SURFACES to be painted as directed.

7451 HOT SURFACES to be painted with approved heat resistant paint.

7501 APPLY PAINT in strict accordance with manufacturer's instructions and recommendations.


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# 492 ELECTRICAL WORK

## PRODUCTS

### 492:A GENERALLY

A105 ELECTRICAL WORK in connection with Plumbing, as described hereinafter, shall be executed as specified under this Section.

A110 STANDARDS: electrical equipment and accessories shall be manufactured in compliance with any of the following standards:

ANSI; NEMA; BS; VDE; DIN; IEC; UTE.

A115 MANUFACTURERS: obtain equipment and accessories from one of the following:

| | |
|---|---|
| GE/AEG | (Germany) |
| Cutler Hammer | (U.S.A.) |
| Alstom | (U.K./France) |
| General Electric | (U.S.A.) |
| Klockner Moeller | (Germany) |
| Merlin Gerin | (France) |
| Siemens | (Germany) |
| EATON | (U.S.A.) |
| Schneider | (France) |

or approved equal.

### 492:H CONDUITS, WIRES AND CABLES

### 492:H1 CONDUITS

H105 SIZE: minimum 20 mm unless otherwise specified.

H110 STEEL CONDUIT: welded, drawn, heavy gauge, to BS 4568 Part 1 or intermediate metal conduit (IMC) to UL1242 and ANSI C80.6 for installations in hazardous, wet and outdoor areas and electrical metallic tubing (EMT) to UL797 and ANSI C.80.3 for indoor installations. Heavy gauge and IMC conduits shall be galvanised externally, galvanised or coated with organic corrosion resistant polymer internally and threaded both ends. EMT conduits shall be non-threaded galvanised externally and protected internally with corrosion resistant enamel (Refer to electrical specification section 218).

H115 FITTINGS: threaded, galvanised or cadmium plated malleable iron.

H120 FITTINGS shall be specifically designed for size and type of conduit.

492:H2 WIRES AND CABLES

H205 POWER WIRES AND CABLES: 450/750 V grade, to IEC 60227-1, IEC 60227-2, IEC 60227-3, IEC 60227-4, IEC 60227-5 and IEC 60227-6 for wires and 600/1000 V grade, to IEC 60502-1, IEC 60502-2 and IEC 60502-4 for cables. Conductors shall be annealed copper. Single conductor wires shall be insulated with moisture resistant flame retardant PVC/C Single and multicore cables shall be insulated with XLPE or PVC/A compound as indicated in the motor control centre schedules or shown on the Drawings, with additional flame retardant PVC/ST2 sheath to IEC 60332-1-1 and IEC 60332-1-2 (Refer to electrical specification section 217).

H210 CONTROL WIRES AND CABLES: conductors to be tinned annealed copper, minimum area 1.5 sq. mm. Insulation to be moisture resistant flame retardant PVC/A compound. Wires to be rated at 450/750 V to IEC 60227-1, IEC 60227-2, IEC 60227-3, IEC 60227-4, IEC 60227-5 and IEC 60227-6. Multicore cables for control and signalling to be PVC/A insulated copper conductors, copper wire or tape screened, flame retardant PVC/ST1 sheathed, rated at 600/1000 V to IEC 60502-1, IEC 60502-2 and IEC 60502-4 and IEC 60332-1-1 and IEC 60332-1-2 as indicated on the Drawings. Core identification is to be white printed numbers over black insulation. (Refer to electrical specification section 217).

H211 CONTROL WIRES AND CABLES: provide special heat resistant insulation or corrosion resistant sheath where required.

H215 ARMOURED CABLES: armour shall be single layer of galvanised steel wire under the PVC sheath for the multicore cables.

H220 CONNECTIONS TO MOTORS: single conductor wires pulled inside conduits, or multicore cables armoured or non armoured and fixed on cable trays or supports.

H225 SPECIAL CONDITIONS: where required high temperature resistant cables, silicone rubber, cross linked polyethylene, MICC, or approved equal, corrosion resistant sheath shall be provided.

## 492:J ELECTRIC MOTORS

J105 MOTORS shall be supplied by driven equipment manufacturer, shall be as specified for equipment concerned and specifically supplied for available supply voltage and frequency.

J106 MOTORS one horsepower and under shall be single phase, and over one horsepower shall be three phase. Motors shall be totally enclosed, fan cooled type (TEFC), IC 411, protected against dust and water to IP54 for indoor installation, IP55 for outdoor installation and to IEC 60034 unless otherwise specified.

J107 MOTORS to have Class F insulation with maximum temperature rise not exceeding class B limits (80ºC) above average ambient temperature of 40 deg. C, unless otherwise specified.

J108 MOTORS that will operate outdoors are to have Class H insulation with maximum temperature rise not exceeding class B limits (80ºC) above average ambient temperature of 40 deg. C. unless otherwise specified.

J109 MOTORS operating in ambient temperatures exceeding 40 deg. C to be tropicalised and de-rated for satisfactory operation.

J110 MOTORS to be rated for continuous operation duty (S1) to IEC 60034. Where specified or recommended by the manufacturer, and approved by the Engineer, motors used for excessive intermittent periodic operation shall be of S3 duty to IEC 60034 and suitably designed for the expected number of starts.

J112 MOTORS FOR VARIABLE FREQUENCY OPERATION to be properly designed and derated for continuous operation with solid state variable frequency drives as specified here-in-after.

J115 POWER to be adequate to operate driven equipment without motor overload under all operating conditions and loads and throughout capacity range of equipment. Motor to be capable of delivering full rated output when operating at voltage deviating by 5% from rated voltage at rated frequency.

J120 STARTING AND TORQUE CHARACTERISTICS to be as required by driven equipment.

J125 SPEED to be as specified for equipment concerned.

J130 CONDUIT TERMINAL BOX ON MOTOR to be approved model for type of motor enclosure. Motor windings to be connected to terminals in terminal box at factory. One additional earthing terminal to be connected to motor frame.

J135 MOTOR BASE to be adjustable where motors are directly connected to driven equipment, unless otherwise specified. Motors connected to equipment through V-belt drive to have adjustable sliding base. Fractional horsepower motors to have slotted mounting holes in base.

J140 MOTOR PROTECTION: provide thermistors embedded in motor windings for thermal protection of motors over 50 HP.

## 492:X COMPONENTS AND ACCESSORIES

### 492:X1 STARTERS

X105 STARTERS for three phase motors to be magnetic or electronic solid state soft type as indicated in the motor control centre schedules or shown on the electrical drawings to automatically disconnect motor from power supply in case of supply failure, excessive voltage drop, over-current and lack of balance in phases. Overload trips to be provided for three phases.

X110 MOTOR DATA: obtain from equipment supplier before ordering any motor starter, or check motor nameplate for full load current rating and allowable temperature rise in order to select proper overload thermal element for motor starter.

X115 SHORT CIRCUIT PROTECTION DEVICE fitted to starter to be independent of controller and overload protection.

X120 CONTROL VOLTAGE for starters and control circuits is not to exceed 110 V.

X125 STEP DOWN CONTROL CIRCUIT TRANSFORMERS: two winding isolating type.

X130 CONTROL CIRCUIT PROTECTION: use high rupturing capacity fuses or circuit breakers.

X135 AUXILIARY SUPPLY for controls, other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

X140 CONTROL DEVICES on starters shall be as follows unless otherwise indicated or required by driven equipment: start stop push buttons, one red pilot light for "running", one green pilot light for "stopped" one amber pilot light for overload trip and one reset push button.

X145 STARTER TYPE A for single phase motors not exceeding 1/2 HP to be surface or flush mounted, manual two pole toggle type, for non reversing across the line starting, fitted with one overload element.

X150 STARTER TYPE B for three phase motors not exceeding 10 HP to be direct on line, non reversing, magnetic type, with manual reset, 3 pole overload relay and under voltage protection, unless otherwise required by local regulations.

X155 STARTER TYPE C for three phase motors over 10 HP, but not exceeding 50 HP, to be automatic star delta magnetic non reversing type, with 3 pole overload relay and under voltage protection, unless otherwise required by local regulations.

X160 STARTER TYPE D for three phase motors over 50 HP to be multiple step auto transformer non reversing magnetic type, with 3 pole overload relay, under voltage protection, unless otherwise required by local regulations. Auto transformer to be dry type, class F insulation, class B temperature rise over ambient temperature. Starter shall be suitable for 15 start per hour repeated after 2 hours for motors up to 200 HP and 3 starts per hour repeated after one hour for motors over 200 HP.

X162 ELECTRONIC SOLID STATE REDUCED VOLTAGE MOTOR SOFT STARTER: shall be UL listed, consisting of silicon controlled rectifier (SCR) based power section, digital logic board and paralleling bypass contactor to provide smooth, stepless acceleration for AC, 3-phase, 380 V, 60 HZ induction motors. The minimum peak inverse voltage rating of the SCR’s to be 1500 V. Contactor to be rated for full voltage across the line motor starting duty. Starter enclosure to be NEMA MG type 12 for indoor installation and type 3R for installations in wet and outdoor areas and provided with necessary ventilation fans. Where shown on the Drawings or indicated in the motor centre schedules, starter shall be incorporated within motor control centre. The starter shall provide the following protections and adjustments:

Adjustable electronic overload

Overheat protection for the starter

Phase sequence protection

Phase loss/unbalance protection

Undervoltage protection

Ramp time

Initial torque

Start current limit

Motor full load current

Starter to comprise moulded case motor circuit protector (with magnetic trip only) for short circuit protection. Starter shall be rated for 125% of the continuous current rating of the motor. Short circuit rating of start shall be at least 110% of the short circuit level at starter location, or as shown on the electrical drawings or indicated in the motor control centre schedules. Soft starters for pumps to comprise smooth soft stop facility for linear voltage deceleration with adjustable deceleration time.

X165 INDIVIDUALLY MOUNTED STARTERS to be totally enclosed in sheet steel enclosure with baked enamel finish. Design is to suit location and application. It is to be impossible to open enclosure door unless isolator is in open position.

X170 NAMEPLATES: starters and controls to have engraved nameplates identifying system or defining its function.

X175 CONTACTORS are to comply with IEC 60947-4, all parts, utilisation category AC3, and/or UL Standard 1008, and be 3-phase, 4-pole, magnetic type, 600 V rating, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to have replaceable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, an inrush current of 20 times normal rating for 4 seconds upon closing and are to be capable of closing on the heaviest short-circuit of the system and withstand the short-circuit for period required by upstream short-circuit protective device to operate. Three N.O. and three N.C. spare contacts are to be provided on each contactor.

X180 STARTER CO-ORDINATION: motor starter devices shall be of type 2 co-ordination to IEC 60947-4-1.

## 492:X2 SWITCH DISCONNECTORS

X205 SWITCH DISCONNECTORS: non fusible, single throw type, with AC-23 utilisation category to IEC 60947-3 for AC motors, housed in separate metallic enclosure, with arc quenching devices on each pole capable of interrupting at least six times its rated current. They are to simultaneously interrupt power supply to all line conductors, any neutral and control circuits.

X206 SWITCH DISCONNECTORS for single phase fractional horsepower motors to be single pole, dolly operated type, rated 15/20 A at 250 V AC, quick make, quick break, with silver alloy contacts, flush or surface mounted to suit application.

X210 OPERATING MECHANISM to be quick make quick break type, with external operating handle mechanically interlocked with enclosure cover to necessitate disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.

X215 ENCLOSURE to be general purpose type, unless otherwise indicated or required, with provision for locking operating handle in OPEN and CLOSED positions.

X216 ENCLOSURES where indicated or required by location to be weatherproof totally sealed water and dustproof type.

## 492:X3 COMBINATION STARTERS SWITCH DISCONNECTORS

X305 COMPONENTS to comprise magnetic starter, switch disconnector and short circuit protection devices required by the Standards, in approved sheet metal enclosure to suit application.

X310 SWITCH DISCONNECTOR OPERATING MECHANISM: quick make, quick break, with external operating handle mechanically interlocked with enclosure cover necessitating disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.

X315 SHORT CIRCUIT PROTECTION GEAR shall be moulded case circuit breakers of appropriate current interrupting capacity.

X320 OPERATION OF CIRCUIT BREAKER to be possible from outside of enclosure. Position of breaker ON/OFF/TRIPPED to be clearly indicated by position of handle.

## 492:X4 PUSH BUTTONS

X405 PUSH BUTTONS to be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads to be colour coded and STOP button to be protected. Push buttons controlling one piece of equipment to be housed in separate enclosure.

## 492:X5 RELAYS

X505 RELAYS to be multipole with normally open or normally closed contacts, electrically operated at 110 V maximum, and magnetically held. Contacts to be double break, silvered type, interchangeable from normally open to normally closed without additional parts. Relays are to be rated at 10 A, 600 V.

## 492:X6 CIRCUIT BREAKERS

X605 CIRCUIT BREAKERS: thermal magnetic type for ratings up to 150 A frame and solid state electronic trip unit for ratings over 150 A frame, with moulded case, manually operated for normal switching functions and automatically operated under overload and short circuit conditions.

X606 CIRCUIT BREAKERS to give positive trip free operation on abnormal overloads, with quick make quick break contacts under both manual and automatic operation. Stationary and movable contacts to be non welding silver alloy adequately protected with effective and rapid arc interruption.

X607 MOTOR CIRCUIT PROTECTOR: moulded case, magnetic break type with adjustable instantaneous setting suitable for motor protection.

X608 MOULDED CASE SWITCH: similar to circuit breakers but without overload/short circuit protection. Short time rating of switches is to be not less than the short circuit current at switch location for 3 cycles. Switches are to have a suitable self-override instantaneous protection and to be in compliance with IEC 60947-3.

X610 BRANCH CIRCUIT BREAKERS to be 100 A minimum frame size, unless otherwise shown on the Drawings.

X615 MAIN CIRCUIT BREAKERS to be 150 A minimum frame size unless otherwise shown on the Drawings.

X616 CIRCUIT BREAKERS AND MOTOR CIRCUIT PROTECTORS are to be in compliance with IEC 60947-2, utilisation category B, sequence II (service capacity) for motor control centres and sequence III (ultimate capacity) for motor control panels and combination starters unless otherwise indicated on the drawings.

X618 ELECTRONIC TRIP UNIT: circuit breaker electronic trip unit shall be provided with adjustable long time, short time and instantaneous current setting. In addition adjustable earth fault protection shall be provided on trip units for main incoming circuit breakers.

X625 MAIN INCOMING BREAKERS / SWITCHES to be equipped to provide earth fault phase failure and phase sequence protection through shunt trip coil. Earth fault detection and interruption to be time co-ordinated with those of main incoming breaker on main distribution board.

X630 MULTIPLE POLE BREAKERS to have single handle mechanism. Each pole to have inverse time delay thermal over-current trip element and magnetic instantaneous over-current trip element for simultaneous tripping of all poles.

X635 TRIP ELEMENTS to be ambient temperature compensated type.

## 492:X8 MOTOR CONTROL PANELS

X805 TYPE: wall mounted or unit mounted, lockable type, IP 42 for indoor installation.

X810 CONSTRUCTION: minimum 1.5 mm thick hot-dip galvanised steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally.

X815 PANELS INSTALLED OUTDOORS AND IN WET AREAS to have weatherproof totally sealed water and dustproof IP 55 enclosures.

X820 COMPONENTS: panels are to contain necessary breakers, starters, push button switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.

X825 LABELS: starters, switches, electrical devices and accessories to be clearly labelled in English as to function and number. Labels to be permanently fixed under each component.

X830 SCHEMATIC AND WIRING DIAGRAMS to be mounted in permanent approved manner on inside of panel door. Diagrams are to show each component cross referenced with component labels.

## 492:X9 CONTROL SWITCHES

X905 FLOAT SWITCH: level operated, heavy duty, bracket mounted type, suitable for application in open tanks, complete with 178 mm spun copper float, brass rod, two stops, floor mounting stand, lever and counterweight. Switch to have oil tight and dust tight enclosure and 2 pole double throw silver contacts that open on liquid rise:

Man: Square D Company
Ref: Type BW 3

or approved equal.

X910 PRESSURE SWITCH: industrial, heavy duty, bellows actuated type, suitable for water service, with contacts to close on falling pressure. Range to be 0.1 to 8 kg/cm2. Switch to be good for 1720 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts and setting adjustment:

Man: Square D Company
Ref: Type ACW-1

or approved equal.

X915 LOW SUCTION PRESSURE SWITCH: industrial, sensitive, low range, diaphragm actuated type, suitable for water service, with range of 2 to 20 kPa of falling pressure, preset at factory to 3 kPa. Switch to be good for 690 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts, range adjustment knob, sealing cap and range locking nut:

Man: Square D Company
Ref: Type AMW-1

or approved equal.

## WORKMANSHIP

## 492:1 GENERALLY

1001 GENERALLY: work is to conform to the requirements of Division 2 Electrical Work.

1051 SHOP AND INSTALLATION DRAWINGS to be submitted for approval prior to ordering materials and equipment. Drawings to include the following:

complete technical data on all motor starters, motor protection relays, sensing units, control accessories, etc.

instructional details of equipment, particularly motor control centers and panels

wiring diagrams of all power and control circuits

installation details of motor control center and panels and of control and sensing accessories

exact routing of power and control cables, wiring and conduits

feeder termination details at motor control centres, starters, motors, isolating switches, control and sensing accessories etc.

## 492:2 WIRING AND CONDUITS

2001 POWER AND CONTROL WIRING: run in conduit unless otherwise specified.

2051 POWER AND CONTROL WIRING: run in separate conduits.

2101 RIGID CONDUITS are not to terminate in nor be fastened to a motor frame or base.

2151 FLEXIBLE CONDUITS to be used at motor connections. Allow sufficient slack to permit motor to slide over adjustable length of motor base.

2152 FLEXIBLE CONDUITS: length and radius to be sufficient to permit bending of feeder cables without damage to conductor or its insulation.

2153 FLEXIBLE CONDUITS: do not use in place of rigid conduit except at motor connections, unless otherwise specified.

2201 SUPPORT CONDUIT with conduit supports in an adequate approved manner.

2251 CONDUITS are not to cross pipe or vent shafts, ducts or openings. They are to be run a minimum 100 mm away from pipes of non-electrical services.

2252 CONDUITS: install so that moisture can drain to lowest point. Provide screw plug at all low points for draining.

## 492:3 CONTROL CIRCUITS

3001 SUBMIT FOR APPROVAL detailed control wiring diagrams and a list of control equipment with descriptive literature. Free hand field wiring diagrams or sketches will not be accepted.

3051 ARRANGE CIRCUITS to satisfy operating requirements specified for various equipment driven by electricity and other requirements pertaining to proper functioning and operation of equipment.

3101 PROTECT CIRCUITS with high rupturing capacity fuses or circuit breakers. Auxiliary supply for controls, other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

## 492:4 EARTHING

4001 EARTH MOTORS by connecting green insulated conductor from earthing bushing in starter to motor frame. Run earth conductor together with circuit wiring and terminate in motor terminal box, provided earth terminal in box is connected to motor frame. If this is not feasible, extend earth conductor through insulated bushed opening in terminal box and connect to motor base.

4051 EARTH EQUIPMENT by connecting non-current carrying metal parts to earth source. Non-current carrying metal parts include conduits, cable trays, outlet boxes, cabinets, enclosures, doors, grilles, and barriers protecting or shielding electrical equipment from direct access.

## 492:5 EQUIPMENT

5001 STARTERS: fix detailed wiring diagram inside enclosure cover to clearly indicate circuits.

5002 STARTERS: identify control and power wires either by distinctive coloured insulation, engraved tags or other approved method.

5051 CIRCUIT BREAKERS: co-ordinate earth fault detection and interruption with those of main incoming breaker on main distribution panel.

5101 PRESSURE SWITCHES: test after installation to ensure dependable operation and correct setting.

5151 LOW SUCTION PRESSURE SWITCHES: test after installation to ensure dependable operation and correct setting.

# 5 HEATING, VENTILATING AND AIR CONDITIONING

## 51 HEATING, VENTILATING AND AIR CONDITIONING - GENERAL

### 511 GENERAL REQUIREMENTS

#### 511:1 DESIGN CONDITIONS

1101 OUTSIDE TEMPERATURES:

| | | |
|---|---|---|
| Summer | : | 32 degrees C dry bulb<br>25.3 degrees C wet bulb |

#### 511:2 DRAWINGS, INSTRUCTIONS AND SAMPLES

2051 EQUIPMENT AND MATERIALS LISTS: within 30 days after the Commencement Date, submit lists of equipment and materials with names of proposed manufacturers and drawings of interrelated items. All submissions are to show submission dates.

2101 SHOP AND INSTALLATION DRAWINGS: at least two months prior to commencement of any installation, submit for approval detailed shop and installation drawings, showing to-scale dimensions of equipment, ducts, pipes etc. in plan and elevation and in relation of same to space assigned.

2102 SHOP AND INSTALLATION DRAWINGS: submit composite installation drawings and sections to a scale of not less than 1/50 showing clearly how work will be installed in relation to the work of other trades.

2103 SHOP AND INSTALLATION DRAWINGS of equipment and material are to include manufacturer's detailed drawings, cuts of catalogues and descriptive literature showing type, performance characteristics, construction, component parts, dimensions, arrangement, operating clearances, capacity, electrical characteristics, power requirements, motor, drive and testing information.

2104 SHOP AND INSTALLATION DRAWINGS: submit manufacturer's certified drawings, templates and installation instructions for all equipment showing operating weights, weight distribution, location of any vibration isolation mounts, size and location of anchor bolts, drains and other openings and all other pertinent data to assist in design of bases and supports.

2105 SHOP AND INSTALLATION DRAWINGS: mark clearly in ink catalogues, pamphlets and drawings for proper identification of item proposed and indicate, with reasons, deviations from the Specification and the Drawings.

2106 SHOP AND INSTALLATION DRAWINGS, lists etc.: submit four copies.

2107 SHOP AND INSTALLATION DRAWINGS: submit for approval in letter form, materials not covered by drawings, e.g. pipes, fittings and incidentals, giving ratings and names of manufacturers.

2108 SHOP AND INSTALLATION DRAWINGS: no equipment or materials to be purchased or delivered to Site until drawings etc. are approved.

2111 FURTHER DRAWINGS: during the progress of the work, submit shop-drawings, to 1/20 or 1/10 scale, as required by the Engineer and as specified elsewhere.

2151 ENGINEER'S DRAWINGS are generally diagrammatic and not to be scaled. Measurements are to be made from established bench marks.

2152 ENGINEER'S DRAWINGS: check all architectural, structural and electrical drawings in laying out work to verify adequacy of space in which work is to be installed. Notify the Engineer where space appears inadequate.

2161 SUBSTITUTION OF EQUIPMENT AND MATERIAL: reference to equipment and material by name, make or catalogue number, and lists of approved manufacturers are to be interpreted as establishing standard of quality and performance and are not intended to eliminate equivalent products of other manufacturers.

2165 PRODUCTS MANUFACTURED LOCALLY in the Middle East, proven to be fully complying with the requirements of this specification including all testing requirements, shall, where indicated, be deemed as “approved equal” to those products of the approved manufacturers referred to within the various sections of this specification.

2201 MINOR CHANGES AND MODIFICATIONS may be made in layout to prevent conflict with work of other trades or for proper execution of the work.

2211 CO-OPERATE with other trades to permit their work to be installed satisfactorily and with minimum interference or delay.

2221 CO-ORDINATE space conditions where work will be installed in close proximity to and may interfere with work of other trades, and accept responsibility for the sufficiency of shafts and chases, clearance in double partitions, suspended ceilings etc. for proper installation of the work.

2231 FURNISH to other trades templates, patterns, setting out plans and shop details necessary for proper installation and co-ordination of adjacent work.

2241 PROTECTION: close open ends of work with temporary covers or plugs during storage and construction.

2301 INSTRUCTION MANUALS: provide six copies in bound booklet form containing the following information:

brief description of each system and piece of equipment with basic operating features

descriptive literature of equipment and components with manufacturer's name, model number, capacity rating and operating characteristics

service manual prepared by manufacturer for every major piece of equipment giving operating and maintenance instructions, starting and shut-down instructions, lubrication instructions and list of possible breakdown and repairs

manufacturer's list of general spare parts for every piece of equipment with unit prices

manufacturer's list of recommended spare parts for one year of operation of each piece of equipment with unit prices

detailed and simplified one line colour coded flow diagram of each system with tag number, location and function of each valve and instrument

detailed and simplified colour coded as-installed wiring diagrams of motor controllers and automatic controls with tag number, location and function of each instrument and electrical device with description of sequence of operation and interlocks.

2302 INSTRUCTION MANUALS: submit in draft form for review and approval prior to final issue at least four weeks in advance of completion date of the system.

2351 RECORD DRAWINGS: submit an approved complete set of as- built drawings and electrical wiring diagrams in tracing or other reproducible form.

2401 SAMPLES: submit for approval samples of proposed materials and workmanship.

## 511:3 ACCESS DOORS AND FRAMES

3101 ACCESS: install work to be readily accessible for operation, maintenance and repair. Approved deviations from the Drawings may be made to accomplish this.

3111 GROUP TOGETHER as practicably as possible concealed valves and devices to be easily accessible through access doors.

3121 PURPOSE: access doors are to be provided for the operation of concealed dampers, damper quadrants, controls, valves, traps, vents, drains, cleanouts, motors, air filters etc.

3141 DETAILS: access doors and frames are to be provided by others. Provide details, dimensions and locations of access doors required and submit for approval in sufficient time to enable access doors to be installed during normal course of work.

3151 IDENTIFICATION: access doors are to be identified to indicate location of concealed work. Method and schedule for identification of access doors is to be approved.

## 511:4 LABELS, TAGS AND CHARTS

4051 NAMEPLATES: each piece of equipment to have a certified nameplate at a conspicuous location, permanently attached at factory, printed or stamped clearly with name and address of manufacturer, equipment model number, serial number, date of manufacture, electrical characteristics, performance rating or duty, pressure, temperature or other limitations and other pertinent data.

4101 LABEL AND IDENTIFY equipment, instruments, controls, electrical devices, valves etc. as to duty, service or function. Label controls and electrical devices to indicate clearly what they control.

4131 LABELS: attach to equipment etc. or to adjacent permanent surfaces in an approved permanent manner.

4132 LABELS: laminated Bakelite with black surface, white core and incised lettering in English.

4201 TAGS: 50 mm diameter by 1.5 mm thick aluminium sheet with stand letters, with heavy aluminium or brass hooks or chains.

4211 TAG controls and instruments that cannot be easily identified with Bakelite labels.

4212 TAG valves and controls, except equipment shut off valves located at equipment.

4251 LABELS AND TAGS: submit for approval a schedule of equipment and devices to be labelled and tagged, with suggested nomenclature.

4301 CHARTS are to be prepared of schematic flow diagrams of each piping system with location and function of each valve and with type and size of each essential feature of the system.

4302 CHARTS: prepare schedules for equipment lubrication and maintenance and essential operating instructions.

4303 CHARTS: submit for approval.

4304 CHARTS: mount on wooden plaques or 6 mm Masonite boards, cover with heat bonded clear plastic laminate or frame under glass, and permanently fix with four brass screws at approved locations.

## 511:5 TRAINING

5051 INSTRUCT AND TRAIN Employer's designated personnel in the operation and maintenance of every part, device and piece of equipment in the system, with emphasis on proper start-up and shut-down procedures, preventive maintenance and lubrication procedures with recommended lubricants, overhaul and maintenance methods, adjustment and calibration of instruments and controls, use of special tools and safe practices.

5061 EXPENSES: the Employer will bear all expenses of his personnel allocated for training.

## 511:6 INITIAL OPERATION OF SYSTEMS

6051 AFTER INSTALLATION IS COMPLETE, operate system for time required to complete tests specified under TESTING, BALANCING AND ADJUSTING, to demonstrate performance in accordance with design requirements and to provide instruction and training to the Employer's designated personnel.

6061 COMMENCEMENT OF DEFECTS LIABILITY PERIOD: to start on the date of substantial completion stated in the Taking-Over Certificate issued by the Engineer, in respect of each system..

## 511:7 NOISE AND VIBRATION

7051 EQUIPMENT is to operate under all conditions of load without objectionable noise or vibration.

7101 NOISE AND VIBRATION noticeable outside a room in which moving equipment is installed, or annoyingly noticeable inside the room, will be considered objectionable.

7151 NOISE LEVEL resulting from equipment and heard in the same building or nearby buildings is not to exceed 40 decibels as measured with a standard sound level meter on the 'A' scale.

7201 CORRECTION: conditions considered objectionable are to be corrected by approved means and as directed.

7211 METHOD OF CORRECTION: noise is to be corrected by addition of sound absorbers in ducts, by internal duct lining, by installation of sound barriers or dampeners on walls and/or ceilings of equipment rooms or by other method to produce satisfactory noise levels.

7251 VIBRATION CONTROL is to be by approved vibration isolators applied and installed in accordance with manufacturer's instructions.

## 511:8 DEFECTS LIABILITY PERIOD

8001 GUARANTEE during the Defects Liability Period is to cover perfect mechanical operation of systems, acceptable noise and vibration levels and reasonable consumption of power, fuel and water.

8051 DEFECTS: if during the Defects Liability Period any equipment or material proves defective or any part of system fails to function properly, equipment is to be replaced and defects and malfunctions corrected as directed by the Engineer.

8101 EXTENSION OF DEFECTS LIABILITY PERIOD: if during the Defects Liability Period any piece of equipment is replaced or rebuilt, the Defects Liability Period is to be extended for this equipment for a new period equal to the original period.

8151 MAINTENANCE AND OPERATION: provide during the Defects Liability Period all necessary skills and labour to assure proper operation and to provide regular and preventive maintenance required for equipment and controls, on a continuous 24 hour basis.

8152 MAINTENANCE AND OPERATION: act promptly to correct problems arising in operation of equipment or system.

8153 MAINTENANCE AND OPERATION: provide the Employer with monthly inspection certificates of equipment, record findings on a check list and certify that each piece of equipment has been examined, is operating as intended and has been properly maintained as recommended by manufacturer.

8154 MAINTENANCE AND OPERATION: check all controls monthly to ascertain that they function as designed.

8201 SPARE PARTS for normal wear and tear are to be provided by the Employer.

## 511:9 STANDARDS

9051 STANDARDS: abbreviations are to mean the following:

| | |
|---|---|
| AGA | American Gas Association |
| AMCA | Air Moving and Control Association |

| | |
|---|---|
| ANSI | American National Standards Institute |
| ARI | Air-Conditioning and Refrigeration Institute |
| ASHRAE | American Society of Heating Refrigerating and Air-Conditioning Engineers |
| ASME | American Society of Mechanical Engineers |
| ASTM | American Society for Testing and Materials |
| BS | British Standards Institution |
| DIN | Deutsches Institut fur Normalisierung |
| FM | Factory Mutual System |
| IBR | Institute of Boiler and Radiator Manufacturers |
| ISO | International Standardization Organization |
| NBS | National Bureau of Standards |
| NFPA | National Fire Protection Association |
| SAE | Society of Automotive Engineers |
| UL | Underwriters' Laboratories Inc. |

# 512 PIPEWORK

## PRODUCTS

### 512:A GENERALLY

A105 REFER TO SECTION 511 GENERAL REQUIREMENTS for requirements common to this and other sections.

A110 BLACK SEAMLESS STEEL PIPE : use for the following services:

fuel lines

A112 COPPER PIPE: use for the following services:

refrigerant lines

### 512:H PIPES AND FITTINGS

### 512:H1 STEEL PIPES AND FITTINGS

H105 PIPES: galvanised or black, seamless or welded as specified to ISO 65 or BS EN 10255.

H107 WALL THICKNESS AND WEIGHT to be as follows:

| Pipe Size mm | Thickness mm | Weight kg/m |
|---|---|---|
| 15 | 2.65 | 1.22 |
| 20 | 2.65 | 1.58 |
| 25 | 3.25 | 2.44 |
| 32 | 3.25 | 3.14 |
| 40 | 3.25 | 3.61 |
| 50 | 3.65 | 5.10 |
| 65 | 3.65 | 6.51 |
| 80 | 4.05 | 8.47 |
| 100 | 4.50 | 12.10 |
| 125 | 4.85 | 16.20 |
| 150 | 4.85 | 19.20 |

H110 GALVANISED PIPES: galvanising to be tested to BS EN 10255.

H115 BLACK STEEL PIPES 200 mm diameter and over to be to BS EN 10216-1, BS EN 10217-1 or equal. Thickness to suit working pressure but not to be less than j (6 mm, 8.2 mm).

H120 FITTINGS FOR BLACK STEEL PIPES AND GALVANISED PIPES: fittings for black steel pipes 50 mm diameter and under and for all galvanised pipes to be screwed malleable iron, 1030 kPa steam working pressure rating, banded type.

H121 FITTINGS FOR BLACK STEEL PIPES over 50 mm diameter to be seamless butt-welding steel, with 37 degrees bevelled ends, of same thickness, schedule and rating as corresponding pipe.

H125 FITTINGS ON FUEL PIPES to be screwed forged steel suitable for backwelding.

H127 PIPE UNIONS to have female threaded ends and ground metal to metal seats.

H128 ELBOWS to be long radius type.

H129 REDUCERS to be concentric or eccentric to suit the application.

H130 FLANGES ON BLACK STEEL PIPES: black forged steel slip- on or weld neck type.

H135 FLANGES ON GALVANISED PIPES: galvanised steel threaded type.

H136 FLANGES: to match flanges provided on valves and equipment in size, thickness, facing, drilling and pressure rating.

H140 GASKETS for flat face flanges to be full face ring type with punched holes, to ASME B16.21, suitable for chemical and thermal conditions of piping system contents; non-metallic, flat, asbestos-free, 3.2 mm thick unless otherwise specified.

H145 GASKETS for raised face flanges to be ring type, to ASME B16.21, suitable for chemical and thermal conditions of piping system contents; non-metallic, flat, asbestos-free, 3.2 mm thick unless otherwise specified.

H150 BOLTS AND NUTS: black steel to BS 4190. Lengths of bolts to allow nuts to utilise full length of thread.

H155 FITTINGS: obtain from one of the following:

| | |
|---|---|
| A.F.L. | (Italy) |
| Crane | (U.S.A.) or (U.K.) |
| George Fisher | (U.K.) |

or approved equal.

H158 DIELECTRIC INSULATED FLANGES to have insulating gasket between flanges and Teflon sleeves and washers between bolts and nuts and the flanges.

H159 DIELECTRIC INSULATED UNIONS AND FLANGES to be suitable for the services and capable of withstanding the temperature, pressure and all other operating conditions of the service.

H160 DIELECTRIC INSULATED JOINTS: obtain from one of the following:

| | |
|---|---|
| Capitol Mfg. Co. | (U.S.A.) |
| Dresser | (U.S.A.) |
| The Duriron Co. | (U.S.A.) |
| Epco Products Inc. | (U.S.A.) |

or approved equal.

H165 THREAD SEALANT: Teflon tape, or approved special joint compound.

## 512:H2 COPPER PIPES AND FITTINGS

H205 PIPES to be drawn or extruded seamless, hard temper copper tube to ASTM B-88 Type L.

H210 WALL THICKNESS to be as follows:

| Pipe Size mm | Outside Diameter mm | Wall Thickness mm |
|---|---|---|
| 6 | 6 | 0.762 |
| 10 | 10 | 0.885 |
| 12 | 12 | 1.016 |
| 15 | 15 | 1.067 |
| 18 | 18 | 1.143 |
| 28 | 28 | 1.270 |
| 35 | 35 | 1.397 |
| 42 | 42 | 1.524 |
| 54 | 54 | 1.778 |

H215 FITTINGS: wrought copper, solder-joint, pressure type, to ASME B16.22, as manufactured by:

Mueller Brass Co. (U.S.A.)

or approved equal.

## 512:H4 PIPE LEAKAGE DETECTION SYSTEM

H405 PIPE LEAKAGE DETECTION SYSTEM to consist of detection or monitoring elements, local alarm stations and Central Control panel. Detection system to be connected to BMS. System to be able to detect and locate exactly the leak over the whole networks of chilled water as shown on the Drawings.

H410 LEAKAGE DETECTION ELEMENTS: to be fully integrated into the insulation envelope.

H415 LEAKAGE DETECTION ELEMENTS: to be installed throughout the piping system and to consist of two coded leak detection copper wire, manufacturing process to guarantee a consistent distance between coded wires and the carrier pipe. In no case the pipe expansion and contraction damages wires or render them ineffective.

## 512:X PIPING ACCESSORIES

### 512:X1 FLEXIBLE CONNECTIONS

X105 TYPE AND RATING: seamless bronze tubing with annular corrugations, covered with high tensile bronze braid, suitable for 150 psi cold water working pressure.

X106 SIZE to be same as pipe run.

X107 ENDS: screwed for pipes 50 mm diameter and under and flanged for pipes over 50 mm diameter.

X108 MANUFACTURERS: obtain from one of the following:

| | |
|---|---|
| Senior Flexonics | (U.S.A.) |
| Keflex Inc. | (U.S.A.) |
| Mason Industries Inc. | (U.S.A.) |

or approved equal.

### 512:X2 EXPANSION JOINTS

X210 TYPE AND RATING: stainless steel, packless, bellows, suitable for 1030 kPa steam working pressure and 1720 kPa cold water working pressure.

X211 SIZE to be same as pipe run.

X212 ENDS: screwed for pipes 50 mm diameter and under and flanged for pipes over 50 mm diameter.

X213 MANUFACTURERS: obtain from one of the following:

| | |
|---|---|
| Senior Flexonics | (U.S.A.) |
| Metraflex | (U.S.A.) |

or approved equal.

512:X3 VALVES

X305 SIZE to be same as pipe run.

X306 RATING: 860 kPa steam working pressure and 1380 kPa cold water non-shock pressure rating.

X307 MANUFACTURERS: obtain from one of the following:

| | |
|---|---|
| Crane | (U.S.A.) or (U.K.) |
| Lunkenheimer | (U.S.A.) |
| Newman Hattersley | (U.K.) |
| Nibco | (U.S.A.) |

or approved equal.

X308 SUBMIT DATA: approval of manufacturer does not necessarily constitute approval of his valves. After award of Contract and prior to start of construction submit for approval a complete summary of valves proposed indicating service, manufacturer, figure number, type and pressure rating.

X309 THREADED VALVES to have BS 21 Taper Pipe Thread.

X310 GATE AND GLOBE VALVES to be capable of being repacked under pressure.

X311 GATE VALVES 50 mm diameter and under to be screwed and have bronze body and trim, solid wedge disc, non-rising stem and screwed bonnet.

X312 GATE VALVES over 50 mm diameter to be flanged and have cast iron body, bronze trim, solid wedge disc, non-rising stem and bolted bonnet.

X313 GLOBE VALVES 50 mm diameter and under to be screwed and have bronze body and trim, integral seat, revolving disc, inside screw, rising stem and screwed bonnet.

X314 GLOBE VALVES over 50 mm diameter to be flanged and have cast iron body, bronze trim, renewable seat and disc, outside screw, rising stem and bolted bonnet.

X315 CHECK VALVES 50 mm diameter and under to be swing pattern, screwed and have bronze body and trim, renewable composition disc and screwed cover.

X316 CHECK VALVES over 50 mm diameter to be swing pattern, flanged and have cast iron body, bronze trim, renewable seat and bolted cover.

X320 SILENT CHECK VALVES to be non-slam, spring loaded, suitable for installation in any position.

X322 SILENT CHECK VALVES 50 mm diameter and under to be screwed, with bronze body, seat and disc, 18-8 stainless steel spring, with body having 2068 kPa working pressure rating.

X324 SILENT CHECK VALVES over 50 mm diameter to be flanged, with cast iron body, bronze seat and disc, 18-8 stainless steel spring, with body having 1720 kPa working pressure rating.

X325 SILENT CHECK VALVES to have straight guided disc with two-point bearing. Wearing parts including disc, seat and other guide bushing to be replaceable.

X330 WEIGHTED CHECK VALVES to have outside lever and weight arranged to assist disc in closing.

X331 WEIGHTED CHECK VALVES: lever to be malleable iron, keyed and locked to extended hinge pin of valve which is to extend from one side of valve body through a special pressure tight stuffing box.

X332 WEIGHTED CHECK VALVES: weight to be cast iron, locked to lever with a set screw so that moving parts operate together.

X333 WEIGHTED CHECK VALVES: over 50 mm diameter to be air-cushioned for non-slam operation.

## 512:X4 RELIEF VALVES

X405 TYPE AND RATING: spring loaded, angle pattern with screwed ends, male bottom inlet, female side outlet, bronze body and trim, suitable for 1030 kPa steam working pressure, complete with hand lever, preset at factory, with pressure setting clearly stamped on nameplate.

X406 MANUFACTURERS: obtain from one of the following:

| | |
|---|---|
| Apco | (U.S.A.) |
| Crane | (U.S.A.) or (U.K.) |
| Newman-Hattersley | (U.K.) |

or approved equal.

512:X5 AUTOMATIC AIR VENTS

X505 TYPE AND RATING: float type with brass base and connection tail. Body, cover, float and vacuum breaker of high quality temperature resisting synthetic material, suitable for atmospheres working pressure and 110 deg. C temperature.

X506 MANUFACTURERS: obtain from:

| | |
|---|---|
| Honeywell Braukmann | (Germany) |

or approved equal.

512:X6 STRAINERS

X605 STRAINERS 50 mm diameter and under to be screwed, Y- type, bronze body, 1030 kPa steam working pressure rating, with 20 mesh stainless steel screen and screwed cap with 15 mm diameter tapped hole for blowdown valve.

X606 STRAINERS over 50 mm diameter on water service to be flanged, basket type with cast iron body, 860 kPa steam working pressure rating with 20 mesh stainless steel basket screen, bolted cap and 20 mm diameter tapped hole at bottom for blowdown valve.

X607 MANUFACTURERS: obtain from one of the following:

| | |
|---|---|
| Crane | (U.S.A.) or (U.K.) |
| Honeywell Braukmann | (Germany) |
| Newman Hattersley | (U.K.) |
| Spinax Sarco | (U.S.A.) |

or approved equal.

## 512:X10 REFRIGERANT PIPING ACCESSORIES

X1005 VALVES to be designed and manufactured for Freon service.

X1006 VALVES: packless type, with flexible metal diaphragm, non-rotating bearing plate, nylon seat disc, stainless steel opening spring, metal handwheel and 'O' ring seal between bonnet and valve body. Forged brass body and bonnet, solder ends and integral support bracket, good for an operating pressure of 2410 kPa and an operating temperature of 4 to 93 deg. C.

X1007 VALVES: valve opening to be full size for maximum flow with minimum restriction.

X1009 CHARGING VALVES to have one end with flare thread, and seal cap and chain.

X1020 EXPANSION VALVES: thermostatic type, forged brass body, stainless steel diaphragm, spring and pushrod, with remote bulb, capillary tube, built-in inlet strainer and external superheat adjustment set for 5.6 deg. C superheat, and correctly sized for coil capacity for efficient refrigerant distribution without starving coil and without hunting.

X1030 SOLENOID VALVES: forged brass body suitable for 1720 kPa Freon operating pressure, solder ends, with means for manual lifting of stem and complete with coil, coil housing and plunger.

X1031 SOLENOID VALVES to be suitable for available current characteristics, and have pressure drop not to exceed 14 kPa at maximum refrigerant flow.

X1040 STRAINERS: brass body suitable for 1720 kPa operating pressure, solder ends and bolted cap to permit removal of strainer screen for cleaning without breaking the inlet and outlet connections. Screen is to be non-corrodible metal of at least 100 mesh with net free area at least 10 times the internal area of the liquid refrigerant pipe.

X1050 FILTER-DRIER: sealed type with solder connections comprising welded steel shell of 17225 kPa minimum burst pressure finished with durable paint for corrosion protection and containing the necessary dessicant and filter media for maximum water capacity and effective filtration with 14 kPa pressure drop at full refrigerant flow.

X1051 FILTER-DRIER: to have spring loaded shock resistant internal construction designed for 100% contact between refrigerant and dessicant under all flow conditions and for preventing by-passing and rupturing.

X1060 SIGHT GLASS: liquid-moisture indicator type, double- ported, solder connections, non-porous forged brass body, 500 psi maximum working pressure, with large, self-cleaning, crystal clear moulded sight glass, special high temperature neoprene seal, with indication to show `full` when system is fully charged and with provision to change colour when a moisture condition exists.

X1070 MANUFACTURERS: obtain refrigerant piping accessories from one of the following:

| | |
|---|---|
| Mueller | (U.S.A.) |
| Sporlan | (U.S.A.) |

or approved equal.

## 512:X11 PIPE HANGERS AND SUPPORTS

X1105 SHOP DRAWINGS: submit drawings of hangers and supports for approval.

X1110 GENERALLY: hangers and supports to allow adjustment of slope of piping and removal without dismantling pipes.

X1111 GENERALLY: hangers and supports to be designed and tested to sustain a load 8 times the actual supported load.

X1112 GENERALLY: hangers and supports to be steel with smooth flat bearing surfaces. They are to carry the weight of piping and contents without sagging, swaying, vibrating or deforming, and to allow free movement of pipes due to expansion and contraction without noise or damage to piping or structure.

X1113 GENERALLY: hangers and supports to be complete with all necessary structural steel, rods, bolts, nuts, turnbuckles and other components.

X1115 SELECTION AND PROCUREMENT to be given early priority during layout phases of design to properly coordinate their installation with the piping erection schedule.

X1125 PIPE INSULATION PROTECTION SHIELDS for use on insulated hot pipes to be galvanised sheet steel 300 mm long, approximately 60 degrees of arc, 3 mm thick for pipes up to 125 mm diameter and 5 mm for pipes over 125 mm diameter.

X1130 PIPE INSULATION PROTECTION SHIELDS for use on insulated chilled pipes between vapour barrier and support to be galvanised sheet steel to fit outside diameter of insulation and cover 180 degrees of arc, 3 mm thick for pipes up to 125 mm diameter and 5 mm for pipes over 125 mm diameter.

X1135 PIPE ANCHORS AND GUIDES: 20 mm diameter U-bolt to fit pipes.

X1140 MASONRY EXPANSION BOLTS: minimum 20 mm diameter.

WORKMANSHIP

512:1 PIPEWORK GENERALLY

1001 INSTALL pipework in accordance with best Engineering practice to present a neat pleasing appearance. Vertical pipes to be plumb and horizontal pipes pitched up in direction of flow to allow for proper venting and drainage.

1051 GROUP pipes together where practicable and run in straight parallel lines close and parallel to walls, ceilings and columns.

1101 CLEARANCE: leave adequate clearance between pipes and adjacent pipes, walls, ceilings and columns for making joints and proper installation of insulation and individual pipe hangers and supports.

1151 ACCESSIBILITY: install concealed piping to permit easy accessibility for maintenance and repair, particularly of valves, vents, drains and other accessories.

1201 AIR POCKETS: install piping to avoid air pockets and dirt traps.

1202 AIR POCKETS: use eccentric reducers where appropriate to avoid air pockets, with the flat of the reducer on top on water piping to permit proper venting of the system.

1251 EXPANSION AND CONTRACTION: install piping to permit free expansion and contraction without damage to piping or structure. Provide adequate offsets and changes of direction to accomplish this, and on long runs provide expansion loops or expansion joints.

1252 EXPANSION AND CONTRACTION: where pipe loops or changes in direction cannot be employed to absorb thermal movement, provide expansion joints and pipe anchors and guides. Install expansion joints in strict accordance with manufacturer's instructions.

1301 INSPECTION: do not paint, cover or enclose piping until it is tested, inspected and approved.

1351 JOINTS are not to be painted, varnished or otherwise coated until tested and approved.

1352 JOINTS: cut pipes square and to exact length, ream cut ends with a special tool to full inside diameter and remove chips.

1401 THREADED JOINTS to be to British Standard Taper Pipe Thread. Cut threads with new dies and remove burrs and chips with a wire brush.

1402 THREADED JOINTS: make up tight close to shoulder of male thread.

1403 THREADED JOINTS: make with red lead on cold pipes and with graphite ground in linseed oil on hot pipes. Apply to male thread only. Teflon tape thread sealant may be used.

1451 FLANGED JOINTS: make perfectly square with pipes. Fit with ring gaskets and assemble with steel square head machine bolts and hexagonal nuts.

1452 FLANGED JOINTS: where flanges on equipment do not match pipe or fittings flanges, provide approved flanged steel adaptors.

1458 JOINTS IN BLACK PIPES 50 mm diameter and under to be threaded. Pipes over 50 mm diameter to be welded.

1460 JOINTS IN GALVANISED PIPES to be threaded for all sizes.

1470 WELDED JOINTS: electric arc welded. Pipes not exceeding 100 mm diameter may be welded by oxy-acetylene torch.

1471 WELDED JOINTS: pipes are to be cleaned free from rust, scale and oxide and bevelled for a V-butt weld.

1475 WELDS: hammer clean and flush out piping to remove scale, welding slag and other debris.

1476 WELDS to be of sound metal and free from laps, gas pockets, slab inclusions, interior protrusions and other imperfections.

1480 WELDERS to be of first class ability with long experience in the trade. Submit names and full qualifications for approval. Welders will be required to demonstrate their capability by welding pipe joint samples before being accepted for the work.

1485 BLACK FITTINGS: not allowed on galvanised pipes.

1490 WELDOLETS AND THREADOLETS of forged steel may be used on black steel pipe branch connections where branch does not exceed half the diameter of main pipe.

1501 PIPE UNIONS OR FLANGES: provide at connections to equipment and near valves, controls, strainers and other accessories requiring removal.

1502 PIPE UNIONS OR FLANGES: provide at adequate intervals in piping to permit easy disassembly.

1503 PIPE UNIONS OR FLANGES: fit between valves and equipment.

1551 EXPANSION JOINTS: when used give consideration to anchoring and guiding pipes for controlled expansion and contraction. Follow instructions of manufacturers.

1601 JOINTS BETWEEN DISSIMILAR METALS: make through dielectric insulated unions and flanges. Use insulated unions on threaded piping and insulated flanges on welded piping.

1651 FITTINGS: changes in direction and size, branching and jointing of pipes are to be made with regular pipe fittings. Do not bend pipe.

1652 PROHIBITED FITTINGS: field fabricated fittings, bushings, close nipples and street elbows are not allowed.

1701 THREADED VALVES: exercise care in installing to avoid straining valve bodies.

1702 THREADED VALVES: when attaching a pipe to a valve in place use a second wrench to hold valve whilst pipe is being tightened. To avoid damage to seat do not screw pipe too far into valve.

1751 GATE VALVES: do not use for throttling purposes such as regulation, balancing or controlling. Use only for shut-off purposes, with the valve in the fully open or fully closed position.

1752 GLOBE VALVE: use where throttling service is required.

1753 CHECK VALVES on discharge of pumps are to be silent type. Those over 50 mm are to be weighted, air-cushioned.

1755 RELIEF VALVES: install where shown on the Drawings, with proper setting to protect equipment and piping from over pressure.

1801 DRAIN VALVES: fix at all low points of piping system and where required to completely drain system.

1851 SHUT-OFF VALVES: fix on branches to isolate sections of piping system for repairs and on each side of equipment.

1901 MANUAL OR AUTOMATIC AIR VENTS: fix at all high points of piping system.

1910 STRAINERS: install where shown on the Drawings and upstream of pumps, control valves and other equipment that may be damaged by suspended particles in the fluid.

1951 CONNECTIONS TO EQUIPMENT: arrange to permit easy removal of equipment without disturbing piping and without interference. Make any reductions in pipe size at equipment or control valves connections with all accessories remaining same as pipe run. Provide flexible connections at rotating or reciprocating equipment.

## 512:2 PIPEWORK SUPPORT - GENERALLY

2001 SUPPORT piping independently of equipment to prevent piping weight or stresses from bearing on equipment connections.

2005 SUPPORT piping at close enough intervals to avoid air pockets and dirt traps.

2051 SPANS: specified maximum spans are for straight runs of pipe.

2101 LOCATIONS: in addition to maximum spans specified, location of hangers and supports is to take into account concentrated loads, elimination of overhung sections or bends, load reaction on terminal connections, pipe expansion and contraction, vibration, hydrostatic testing, water hammer and seismic forces.

2102 LOCATIONS: reduce support spacing to less than three quarters of maximum spans where changes in direction or branch connections occur.

2103 LOCATIONS: locate supports immediately adjacent to any change in direction of piping, at branch connections and at concentrated loads.

2105 STRENGTH: hangers and supports to be capable of carrying weights of pipe, valves, fittings, insulation, suspended hanger components, appurtenances and contents.

2201 FIX supports to structure with masonry expansion bolts without causing overstress to the structure.

2202 FIX: provide intermediate steel where required to transfer loads to areas of structure where they can be safely accommodated.

2251 MASONRY EXPANSION BOLTS: drill for in structure and install in accordance with manufacturer's instructions.

2301 MULTIPLE PIPE RUNS: where bottoms of lines are approximately at same level, support in groups on trapeze hangers. Keep pipes in position with U-bolts.

2351 TRAPEZE HANGERS: maximum spacing is to be that for smallest pipe supported.

2401 SPRING CUSHIONS: use where a horizontal pipe is subject to considerable vertical movement or vibration.

2451 RISERS: support independently of adjacent horizontal hangers.

2500 SUPPORTS FOR INSULATED PIPES: protect insulation at support points against damage from pipe weight or movement, without affecting the firm attachment of pipes to their supports.

2501 INSULATED HOT PIPES: lugs may be welded to pipes and extended outside the insulation to a hanger attachment, or if supported from below, to a sliding shoe or roller supports.

2601 ANCHORS: weld U-bolts to pipes at points of contact and bolt to structural angle frame securely fixed to structure.

2605 EMBEDDED INSERTS: install during concreting.

2651 PROHIBITED HANGERS AND SUPPORTS: do not use wire, metal bands, rope, wood, chain, strap or perforated bar. Do not hang pipes from other pipes. Do not use temporary makeshift arrangements to support pipes in place of proper hangers and supports.

512:3 STEEL PIPING

3051 HORIZONTAL PIPE: support at intervals not exceeding the maximum support spacing and by hanger rod of minimum size as follows:

| Pipe Diameter mm | Maximum Support Spacing mm | Minimum Size of Hanger Rod mm |
|---|---|---|
| 15 | 1.5 | 10 |

| | | |
|---|---|---|
| 20 | 1.8 | 10 |
| 25 | 2.0 | 10 |
| 32 | 2.5 | 10 |
| 40 | 2.7 | 10 |
| 50 | 3.0 | 10 |
| 65 | 3.3 | 12 |
| 80 | 3.6 | 12 |
| 100 | 4.2 | 16 |
| 125 | 4.8 | 16 |
| 150 | 5.2 | 20 |
| 200 | 5.8 | 22 |

3101 VERTICAL PIPE: support at a minimum of every storey height.

512:4 REFRIGERANT PIPING

4002 SUPPORT piping from ceilings with adjustable, split- ring hangers with threaded hanger rod and ceiling flange. Support horizontal pipes run along walls on brackets.

4003 SUPPORT piping at not more than 2 m intervals.

4005 SUPPORT valves independently pipes.

4051 HANGERS AND SUPPORTS: locate at not more 600 mm from each change of direction, preferably on side with longest run.

4101 HANGERS AND SUPPORTS on straight runs of pipe over 6 m long are to allow for thermal movement of pipe.

4151 HANGERS AND SUPPORTS on insulated pipes are to bear on outside of insulation, with a protective shields placed between insulation and hanger.

4201 JOINTS: make by silver brazing, using 45 per cent silver brazing alloy and a good grade of silver brazing flux. Do not bend pipe.

4241 VALVES: install in each refrigeration system all necessary service valves, charging valves and safety valves, whether shown on the Drawings or not.

4251 SOLENOID VALVES: install in liquid line upstream of each expansion valve.

4261 STRAINERS: install upstream of expansion valves and other control valves that do not have built-in strainers.

4301 SIGHT GLASSES: install in liquid line before the filter- drier to indicate adequacy of refrigerant charge and existence of moisture.

4311 FILTER-DRIERS: install in liquid line of each refrigeration system to remove moisture, acids and solid contaminants.

4351 PRESSURE TEST refrigeration systems with nitrogen gas from a pressurised cylinder to 2060 kPa on high pressure side and to 1030 kPa on low pressure side. System is to have no loss of pressure for 4 hours. Test for leaks with a soap solution.

4401 VACUUM TEST refrigeration systems after pressure test. Evacuate system with a vacuum pump to a vacuum of 635 mm of mercury. System is to hold vacuum for 24 hours.

4451 CHARGE refrigeration systems following vacuum test with the correct quantity of refrigerant. Test with a halide torch to prove tightness under actual operating conditions.

512:9 CLEANING

9001 CLEAN WATER SYSTEMS after completion by flushing with clean water.

9002 CLEAN REFRIGERANT SYSTEMS after completion by blowing with compressed air.

9051 SCAVENGE WATER PIPING SYSTEMS on completion. Fill system with clean water, add an alkaline detergent such as sodium silicate and/or sodium phosphate to obtain a phenolphthalein alkalinity of 2000 to 5000 ppm as CaCO3 in the system. Add a non-foaming wetting agent. Circulate water in the system at the design flow rate for a period of three 8 hour days. At the end of each day remove and clean strainers and blow off all low points.

9052 SCAVENGE WATER PIPING SYSTEMS: after third day of pumping, drain system, refill with clean water and circulate for 8 hours. Drain system, refill and circulate. Test

water for alkalinity, which is not to exceed 200 ppm in excess of alkalinity of rinsing water. Repeat procedure until this alkalinity or less is achieved.

# 52 DUCTWORK

## 521 DUCTWORK

PRODUCTS

### 521:A GENERALLY

A105 REFER TO SECTION 511 GENERAL REQUIREMENTS for requirements common to this and other Sections.

A110 DUCT WEIGHTS for payment purposes to be based on length of ducts installed. Rates to be calculated taking into consideration losses, joints, seams etc.

### 521:H DUCTS AND DUCTWORK ACCESSORIES

### 521:H1 DUCTS

H105 MATERIAL: galvanised steel to ASTM A53/A53 M standard specification for steel sheet, zinc coated or zinc-iron-alloy coated (galvannealed) by the Hot-Dip Process, coating designation G90 or approved equivalent standard with minimum weight of zinc coating (total on both sides) of 275 g/m2 (0.90 oz per sq.ft).

(j) coating designation G115 or approved equivalent standard with minimum weight of zinc coating (total on both sides) 351 g/m2 (1.15 oz per sq.ft).

H110 MINIMUM GAUGE AND THICKNESS OF SHEET METAL to be not less than as follows:

| Size of Duct mm | U.S. Galvanised Sheet Gauge | Minimum Thickness mm |
|---|---|---|
| up to 300 | 26 | 0.6 |
| 330 to 760 | 24 | 0.7 |
| 790 to 1370 | 22 | 0.9 |
| 1400 to 2130 | 20 | 1.0 |
| 2160 and larger | 18 | 1.3 |

H120 KITCHEN EXHAUST DUCTS: comply with NFPA 96. Ducts shall be constructed of and supported by j (black steel sheets of minimum thickness 1.4mm, stainless steel

sheets of minimum thickness 1.1mm), and made liquid tight with continuous external weld for all seams and joints. Provide access doors and panels for duct cleaning at maximum 3.7 m intervals, and at each change of direction. Access doors or panels shall be of the same material and thickness as the duct, with gaskets and sealant that grease tight and rated 815 deg.C. Same gasket and sealant shall be used between different steel ducts whenever the case occurs.

H125 WET AIR EXHAUST DUCTS: ducts for dishwashers shall be constructed and supported by stainless steel sheets of minimum thickness 1.1mm, and made liquid tight with continuous external weld for all seams and joints. Provide gaskets and sealant between different steel ducts whenever the case occurs. Provide access doors and panels with gaskets and sealant at each change of direction.

## 521:H2 DUCTWORK ACCESSORIES

H205 FLEXIBLE CONNECTIONS: 567 grams chemically impregnated fire retardant canvas, crimped for flexibility. Length of flexible part to be not less than 150 mm and not more than 300 mm.

H206 CLAMPING COLLAR for flexible connection to be 30 mm wide x 1.5 mm thick galvanised sheet steel.

H210 SPLITTER VANES to be galvanised sheet steel blade, at least 1 mm thick, crimped over at end, attached to a 10 mm diameter pivot rod with flat lugs welded to rod and bolted to blade with three stove bolts per lug. Rod is to pass through duct at both ends through tight fitting bushings attached to duct walls. Rod is to completely clear bushing at one end and pass through damper operating quadrant at other end.

H211 SPLITTER VANES to be operated by damper quadrant from outside the duct.

H212 SPLITTER VANES to be long enough to completely close off air flow to duct branch on which it is installed.

H215 VOLUME CONTROL DAMPERS: butterfly or multi-blade type, operated by damper quadrants from outside the duct.

H216 VOLUME CONTROL DAMPERS: butterfly dampers are to be single flat galvanised sheet steel blade, with pivot rod fitted to centre of blade as specified for SPLITTER VANES. Maximum single dimension is not to exceed 1 m.

H217 VOLUME CONTROL DAMPERS: reinforce butterfly blades longer than 300 mm with 30 x 30 x 3 mm thick angles and fix damper stops of same size angles inside duct. Fix angles to blade and to duct by rivetting. Angles are not to interfere with operation of damper or cause additional turbulence.

H218 VOLUME CONTROL DAMPERS: multi-blade dampers are to comprise linked blades of not less than 1.5 mm thick galvanised sheet steel of maximum 150 mm x 600 mm dimensions, installed inside a galvanised steel frame. Multi-blade dampers may be either opposed-blade or parallel-blade type.

H219 MOTORISED DAMPERS to be opposed blade action type with galvanised steel blades mounted in galvanised steel frame on nylon bearings and linked together to operate simultaneously. Blades to have seamed in, felted edges to hold air leakage and air noise to a minimum. Frame to be suitable for installation in a duct or wall. Damper motor to be line voltage, two-position, spring return type:

Man: Honeywell
Ref: damper: model No. D641
damper motor: model No. M436

or approved equal.

H220 FIRE DAMPERS: 3 mm thick black steel plate, with frame and blade designed to cause no obstruction to airflow in the open position. Damper to be weighted to close promptly when released, regardless of airflow pressure. Blade to be hung on zinc-coated hinges with loose fitting brass pins and bushings. Blade to close tightly against angle stops and have retaining springs. Blade to be held open by fusible link having a melting temperature not higher than 75 deg. C.

H225 DAMPER QUADRANTS: galvanised steel or other corrosion resistant metal, with lever and lock screw for fixing in any position and to give clear indication of splitter or damper position.

H235 ACCESS DOORS in ductwork to be galvanised steel sheet, fabricated in same manner as ductwork, braced and reinforced for rigidity and having hinge on one side and latch on other side.

H236 ACCESS DOORS to be 500 mm x 350 mm except on ducts less than 400 mm in width where they are to be 500 mm wide with other dimension 50 mm less than duct width. Access doors may be larger size where required for access.

H240 FILTER BOXES: galvanised sheet steel, fabricated in same manner as ductwork, with filter racks for 50 mm thick air filters and access doors for easy removal of filters

from either side. Boxes are to have cross-sectional face area to limit velocity through filters to 1.8 m/s with means for installing a standard, formed steel outside air louvre on inlet and for attaching a tapered transition duct piece to fan suction.

H241 FILTER BOXES to have necessary number of standard 300 mm x 300 mm x 50 mm thick air filters to fit racks and butt tightly against each other to preclude air bypass. Air filters to be permanent, cleanable, aluminium type.

H245 NUTS, BOLTS, SCREWS AND OTHER HARDWARE: to be of materials identical or similar to duct to prevent galvanic corrosion. Zinc or cadmium plated hardware is permitted on galvanised ducts.

## 521:H3 DUCTWORK SUPPORTS

H305 HORIZONTAL DUCTS SUPPORTS: trapeze type comprising 50 x 50 x 5 mm angle iron 200 mm longer than duct width, supported from ceiling by two 20 mm round steel rod hangers with threaded ends, one end fixed to angle with nuts and washers, other end fixed to ceiling with 20 mm masonry expansion bolts.

H308 VERTICAL DUCTS SUPPORTS: 50 x 50 x 5 mm angle iron riveted to duct and extended to rest on floor or on similar angles cast in the wall.

## 521:H4 DUCT SEALANTS

H401 DUCT SEALING COMPOUND: as per:

Man: 3M
Ref: Brand No. 700 for brush application,
Brand No. 90 for other applications

or approved equal.

H402 DUCT SEALING TAPE: as per:

Man: 3M
Ref: Brand No. 474

or approved equal.

WORKMANSHIP

521:1 DUCTWORK FABRICATION

1001 CONSTRUCT ductwork in a sturdy, neat, tight manner in accordance with ASHRAE Standards. Make casing and plenum joints square and remove sharp edges. Seams are to be double lap. Slip joints to have smooth interior surface, made in direction of air flow and continuous around four sides. Slips to be at least one gauge heavier than ducts.

1010 BRACE AND STIFFEN ductwork so that it does not vibrate, rattle, 'breathe' or sag. Bracing to be on outside of ducts and to consist of standing seams, angles and cross-breaking of duct panels.

1020 REINFORCE AND STIFFEN ductwork at damper locations, at access door locations and at other locations as required.

1025 UNINSULATED DUCTS larger than 460 mm are to be cross- broken.

1030 JOINTS AND SEAMS: make airtight with sealing compound during fabrication and after erection of ductwork.

1035 CHANGES IN DIMENSIONS AND SHAPE: make with as long a taper as possible.

1040 CURVES, BENDS AND OFFSETS: make with large radii, with average centreline radius not less than one and a half (1 1/2) times width of duct.

1045 TURNING VANES: provide inside elbows where conditions necessitate elbows with radii less than 1 1/2 times width of duct. Space turning vanes in accordance with ASHRAE Standards.

1050 SPLITTER VANES: provide at all branches in duct for adjusting and balancing air flows to different branches. Fit in duct in an approved manner to prevent rattling and vibration.

1055 JOINTS BETWEEN DISSIMILAR METALS: make with angle iron companion flanges separated by compressed asbestos composition gasket.

1060 SCREWS: do not use sheet metal screws in construction of ductwork.

1201 ACOUSTIC LINED DUCTS: make larger to accommodate specified thickness of lining whilst retaining internal dimensions of duct indicated on the Drawings.

## 521:2 DUCTWORK INSTALLATION

2001 ROUTE ductwork directly with a minimum of directional changes and abrupt transitions.

2051 INSTALL ductwork allowing adequate space for fixing supports and insulation.

2101 INSTALL ducts, casings, plenums and hangers straight, plumb and level.

2151 SUPPORT ductwork in a rigid manner to prevent vibration and sagging. Do not use loose blocking or shimming between ducts and supports or between supports and structure. Cross break duct panels where required for rigid support.

2201 SUPPORTS: install on outside of ducts. No support or hanger rod is to pierce or go through duct. No sheet metal screws are to be used in attaching supports to duct.

2251 HORIZONTAL DUCTS SUPPORT: maximum spacing of supports is to be as follows:

| Duct Cross-Sectional Area | Maximum Spacing of Duct Supports |
|---|---|
| Up to 0.37 sq.m. | 3.0 m |
| 0.37 to 0.93 sq.m. | 2.0 m |
| Exceeding 0.93 sq.m. | 1.2 m |

2301 VERTICAL DUCTS: support at each storey height with a minimum of two supports per duct, one each side.

2351 VERTICAL DUCTS: where more than one duct is supported by a common set of angles, where span of angles exceeds 2 m or where floor to floor height exceeds 4 m, increase size of support as required.

2751 DUCTS PASSING THROUGH STRUCTURE: where ducts pass through walls, partitions and floors (except in shafts) seal around duct with asbestos rope, mineral wool or other approved non-combustible material.

2801 PROTECTION: cover open ends of ducts with canvas during construction.

2851 CLEAN ductwork inside and outside before applying insulation and before installing filters and operating fans.

## 521:3 DUCTWORK ACCESSORIES

3001 FLEXIBLE CONNECTIONS: provide between ductwork and air handling equipment and where indicated. Securely fasten to duct and seal with special sealing compound. Slip flexible connection over a 100 mm long matching sheet metal sleeve in the duct and clamp to duct with clamping collar. Secure clamping collar to duct with galvanised bolts and nuts.

3003 ACCESS DOORS: provide in ducts for access to duct mounted equipment requiring inspection, maintenance or operation, on entry and exit sides of coils and fans and on linkage side of dampers.

3004 ACCESS DOORS on insulated ducts are to be insulated in same manner as duct. Insulate separately to permit opening.

3051 AIR FILTERS in ducts are to be installed in an approved tight manner and provided with access doors.

3101 FILTER BOXES: install on suction side of fresh air supply fans.

3351 DAMPER QUADRANTS: provide for operation of splitter vanes and volume control dampers from outside the duct. Fasten securely to duct with stove bolts. Do not use sheet metal screws.

3355 INSTALL multi-blade type volume control damper when width of damper blade is over 300 mm.

3360 FIRE DAMPERS: install without strain or distortion of any part and so that all moving parts move freely. Caulk tight around frame which is to extend full thickness of wall or floor. Provide access door in duct for replacement of fusible link.

3361 FIRE DAMPERS: single blade pivot type to be used in both vertical or horizontal ducts.

3362 FIRE DAMPERS: rectangular multi-blade type to be used in horizontal ducts only.

3365 CLEAN washable air filters after tests and reinstall.

3370 REPLACE throwaway air filters after tests.

# 53 AIR OUTLETS

## 531 AIR OUTLETS

### PRODUCTS

### 531:A GENERALLY

A101 REFER TO SECTION 511 GENERAL REQUIREMENTS for requirements common to this and other Sections.

A102 MATERIAL: extruded anodised aluminium unless otherwise specified.

A103 SIZE: as indicated on the Drawings.

A104 FINISHES: air outlet finishes referred to in this Section are indicative only. Actual finishes to be provided will be required to closely match architectural components, and shall be subject to prior approval by the Engineer.

A105 MANUFACTURER: as far as practicable air outlets are to be the products of one manufacturer.

A110 APPROVED MANUFACTURERS: obtain air outlets from one of the following:

| | |
|---|---|
| Anemostat | (U.S.A.) |
| Barber Colman Co. | (U.S.A.) |
| Euro Register | (Belgium) |
| France Air | (France) |
| Hart & Cooley | (U.S.A.) |
| Ruskin | (U.S.A.) |
| Titus | (U.S.A.) |
| Trox | (U.K.) |
| Waterloo | (U.K.) |

or approved equal.

A115 SUBMIT DATA: 'approved manufacturers' does not necessarily mean approval of their products. Immediately after award of Contract and prior to commencement submit for approval a complete list of proposed air outlets, indicating manufacturer, catalogue number, details of construction and performance.

A120 NOISE LEVEL: size air outlets for minimum noise levels, not to exceed 40 db at specified air quantity, as measured on the A-scale of a standard noise level meter, unless specified otherwise.

A125 GASKETS: felt or sponge rubber, to be fitted at factory on all air outlets to prevent air leakage and dust streaking of walls and ceilings.

A130 SCREWS used in fixing air outlets to be chrome or cadmium plated.

531:H AIR OUTLETS

H105 CEILING DIFFUSERS: select to give required throw to nearest wall. Terminal velocity is not to exceed 0.5 m/s at specified air quantity. Velometer velocities through diffuser are not to exceed 3.8 m/s.

H106 CEILING DIFFUSERS are to deliver air for cooling at 14 deg. C below room temperature and for heating at 33 deg. C above room temperature without causing objectionable conditions.

H107 CEILING DIFFUSERS to have flange suitable for flush mounting on false ceiling and round neck sized to fit outside duct. They are to be complete with volume control damper accessible from face of diffuser and equalising deflectors to provide an even air discharge pattern.

H110 ROUND CEILING DIFFUSERS: three cone adjustable type.

H115 SQUARE AND RECTANGULAR CEILING DIFFUSERS: two-piece design consisting of mounting frame and removable core attached with spring lock.

H125 LINEAR DIFFUSER: factory supplied diffuser plenum fittings are to be coated steel insulated internally with 12 mm thick duct insulation.

H130 AIR SUPPLY REGISTERS: double deflection type with individually adjustable horizontal face bars, vertical rear bars and vertical, opposed-blade, key-operated volume control dampers accessible through face of register.

H135 AIR SUPPLY GRILLES: type specified for air supply registers but without volume control damper.

H140 AIR SUPPLY REGISTERS AND GRILLES: select for correct deflection to suit shape of room. Terminal velocity at end of throw to opposite wall is not to exceed 25 m/s at specified air quantity. Velometer velocities through register or grille are not to exceed 3.8 m/s.

H145 RETURN AIR GRILLES: fixed blade type with blades set at 45-degree deflection parallel to long dimension. Grille net free area is to be not less than 70% of gross face area. Size for face velocities to be as follows:

| Grille Location | Velocity Over Gross Area |
|---|---|
| above occupied zone | 3.0 - 4.0 m/s |
| near floor level | 2.0 - 3.0 m/s |
| door or wall louvre | 1.0 - 1.5 m/s |

H150 TRANSFER GRILLES to be fixed blade type with blades set at 45-degree deflection parallel to long dimension. Grille net free area not to be less than 70% of gross face area.

H170 RETURN AIR, OUTSIDE AIR AND EXHAUST REGISTERS to have fixed, 25 mm wide, horizontal louvres set at 45-degree deflection, spaced at 20 mm centres and equipped with vertical, opposed-blade, key-operated volume control dampers accessible through face of register.

H175 OUTSIDE AIR LOUVRES: galvanised heavy gauge formed steel consisting of 100 mm wide stationary blades set at a 45-degree angle inside a channel frame. Assembly to be pre-bonderized steel, with grey coat hard baked enamel finish.

H176 OUTSIDE AIR LOUVRES to be equipped with a 12.7 mm mesh by 1 mm diameter bird screen in extruded aluminium U-shaped frame designed to fit on interior face of louvre.

H180 SAND TRAP LOUVERS to be provided where indicated on Drawings. Sand trap louvers shall be fixed vertical blade type a minimum of 300 mm deep, fabricated from extruded aluminium members, of minimum 2 mm thick 6063-T5 alloy. The louver sub-sill shall be formed from 1.25 mm thick aluminium sheet and sloped at such an angle as to direct captured sand to the building exterior. Louvers to be self cleaning and maintenance-free.

H181 SAND TRAP LOUVERS: shall be tested by an accredited laboratory to confirm and certify the louver system's ability to reject a minimum of 95% of sand grain sizes between 150 and 425 microns when subjected to a face velocity of 0.5 m/s.

H182 SAND TRAP LOUVERS: finish to be powder coated for the application.

H183 SAND TRAP LOUVERS: an indoor screen of stainless steel construction and 12 mm mesh shall be provided on the inside of each louver.

H184 SAND TRAP LOUVERS: to be as manufactured by:

Trox

or approved equal.

H190 AUTOMATIC AIR DAMPERS: vertical, back draught or barometric type that open under air pressure to allow air to escape from room, fan plenum or duct and that close by weight of blades to prevent air from passing in reverse direction.

H195 AUTOMATIC AIR DAMPERS to consist of multiple blades of light aluminium, mounted inside aluminium or galvanised steel frame on nylon bearings and linked together to operate in parallel. Blades to have seamed-in, felted edges to hold air leakage and noise to a minimum. Frame to be suitable for installation in duct or wall.

H198 DOOR GRILLES: no-vision, V-shaped louvre type. Grille net free area to be not less than 70% of gross face area.

## 531:H2 WORKMANSHIP

## 531:1 AIR OUTLETS

1001 INSTALL in an approved, neat, level, square, tight manner.

1051 OUTLETS INSTALLED DIRECTLY ON DUCTS: fit to appropriate sheet metal flange formed integrally from duct and fix with sheet metal screws.

1061 OUTLETS INSTALLED IN WALLS OR FURRED-IN DROP CEILINGS: fit to appropriate wooden frame provided around opening. Fix to frame with chrome plated or cadmium plated wood screws. Provide duct collar to finish flush with external surface of frame and nail to frame to make tight connection. Frame to be size to be completely concealed by air outlet flange.

1101 CEILING DIFFUSERS: do not locate near columns or other obstructions or very near to side walls, to avoid causing objectionable draughts, unless they are specifically selected to suit the application, such as one-way, two-way or three-way blow.

1151 LINEAR DIFFUSERS: where feasible use factory supplied diffuser plenum fittings in place of field fabricated duct plenums.

# 54 EQUIPMENT

## 541 EQUIPMENT - GENERAL

PRODUCTS

### 541:A GENERALLY

A101 REFER TO SECTION 511 GENERAL REQUIREMENTS for requirements common to this and other Sections.

A105 PAINT FINISH: equipment to have factory applied finish coat of machinery enamel unless otherwise specified.

A110 WARRANTY: equipment is to carry manufacturer's warranty against defects in materials and workmanship.

A115 FURNISH equipment supplier with all necessary data such as available electric current characteristics, maximum and minimum ambient temperatures and humidities, altitude, water quality and other particular site conditions so that manufacturer will supply equipment to specifically suit Site conditions particularly for necessary derating in capacity for altitude and temperature, necessary class of insulation for electric motors, special construction for water quality, high temperatures and humidities, sandy environment etc.

A120 ELECTRIC MOTORS to conform with the specification for electric motors given under ELECTRICAL WORK and with requirements given under equipment specifications for particular motor driving that equipment.

A125 SUPPLY EQUIPMENT from factory complete with all necessary accessories and components that are standard items of manufacturer or as recommended by him for good, safe and efficient operation of equipment irrespective of whether these are specified or not.

A130 REJECTION: the Employer or the Engineer may reject any equipment proposed even though it conforms to the Specification if, in his opinion, equipment is of inferior quality or performance to that which is intended.

A201 FLOOR-MOUNTED EQUIPMENT: unless otherwise indicated, provide concrete bases and/or support pads under all floor-mounted equipment, including but not limited to, condensing units, pumps, fans, compressors and air handling units, in accordance with the requirements specified in Section 591 – Builder's Work.

# 548 ACCESSORY AND MISCELLANEOUS EQUIPMENT

## PRODUCTS

### 548:Y MISCELLANEOUS EQUIPMENT

### 548:Y5 SPLIT ROOM AIR CONDITIONERS

Y501 SPLIT ROOM AIR CONDITIONERS: unit shall comprise of an indoor unit and an air cooled outdoor unit for application with R-22 refrigerant. The air conditioning unit shall be capable of handling the cooling loads when operating at the ambient design conditions at the medium fan speed.

Y505 INDOOR UNIT (FCU):

cabinet to be of the decorative type for exposed usage and to be constructed of finished steel with baked resin paint. The cabinet interior to be fully insulated to prevent sweating and to muffle the sound. (Cabinets made partly out of plastic shall be acceptable).

evaporator coil shall be multi-pass cross finned tube equipped with aluminium plate fins, mechanically bonded to seamless oxygen - free copper tubes. The coil shall be cleaned, dehydrated and tested for leakage at the factory. Coil face velocity shall not exceed 2.5 FPM.

evaporator fan to be forward curved centrifugal type, statically and dynamically balanced and directly driven by the motor. The fan motor shall be permanently lubricated. The evaporator fan must be selected to operate quietly with no overloading of fan motors.

air filter to be washable type, long life as per manufacturer's standard.

refrigerant circuit to have one-shot couplings or isolating valves at liquid inlet and gas outlet, a capillary tube and a strainer.

drain pan to be sturdy metallic, treated for corrosion resistance, insulated and easily accessible for cleaning/maintenance.

sound level not exceed NC 30 at low speed and NC 35 at high speed when measured at one meter distance in a room with normal occupancy and furnishing.

Y510 UNIT CONTROL: unit shall be equipped with an operation switch, fan speed selector switch and a thermostat mounted on the control panel. The control system shall

permit manual starting and automatic continuous operation whenever the thermostat requires and the protection devices allow.

The ceiling/wall suspended unit shall be equipped with remote type control box having thermostat, OFF/FAN/COOL and speed selection switch. The floor mounted unit shall be equipped with control panel built-in within the unit. Thermostat of the type lockable at the extreme setting shall not be acceptable.

Y515 OUTDOOR UNIT (CU):

outdoor unit to be factory assembled, piped internally, prewired and shall be designed to operate at outdoor design ambient temperature.

cabinet to be constructed of finished steel with baked synthetic resin paint. The fan guard shall be adequately protected against corrosion.

unit to contain a hermetic compressor with internal suspension and welded shell. Suitable vibration isolators shall be provided external to the compressor.

condenser coils to be multi-pass cross-finned type equipped with aluminium plate fins mechanically bonded to seamless copper tubes. The coil shall be cleaned, dehydrated and tested for leakage at the factory.

condenser fan to be propeller type with aluminium blades, statically and dynamically balanced and driven directly by fan motor for up-flow or side-flow air discharge as shown on drawings. The motor shall be permanently lubricated and shall be protected from water invasion.

refrigerant circuit to have one shot couplings or isolating valves at liquid outlet and gas inlet.

rubber pads for vibration isolation shall be not less than 10 mm thick.

Y520 REFRIGERANT PIPES: copper, insulated, pre-charged from factory.

Y521 CAV BOXES:

Model ESMB room bypass terminals vary the volume of air supplied to the room by diverting 0 to 100% the air through a bypass opening and into the system return. While the room air supply varies, the supply fan operates at constant volume.
Durable rubber seal on outlet and bypass opening which the diverter plate closes against.

24 volt electric actuator is an integral part of the bypass terminal.

Heavy gauge steel housing.

Diverter plate rides on heavy duty self lubricating bearings.

Dual density insulation is coated to prevent air erosion. Meets requirements of NFPA 90A, and UL181.

# 56 INSULATION

## 561 INSULATION

### PRODUCTS

### 561:A GENERALLY

A105 MATERIALS: shall be compatible and shall not contribute to corrosion, soften, or otherwise attack surfaces to which they are applied in either the wet or dry state. Materials shall be asbestos free.

A110 THERMAL-INSULATION SYSTEM MATERIALS shall be noncombustible, as defined by NFPA 220. Adhesives, coatings, sealants, facings, jackets, and thermal-insulation materials, except cellular elastomers, shall have a maximum flame-spread classification (FSC) of 25 and a maximum smoke-developed classification (SDC) of 50. Flame-contributed classification (FCC) shall be as specified for the application. These maximum values shall be determined in accordance with NFPA 255.

A115 ADHESIVES, COATINGS, AND SEALANTS shall be nonflammable in their wet state. Adhesives, coatings, and sealants shall have published or certified temperature ratings suitable for the entire range of working temperatures normal for the surfaces to which they are to be applied.

A120 CONDUCTANCE: insulation material shall be maximum values, as tested at any point, not an average. Insulation conductance found by test to exceed the stipulated maximum shall be either be replaced or augmented by additional thickness to bring it to the required maximum conductance.

A125 GLASS-FIBRE BLANKET THERMAL INSULATION: Glass fibres bonded with a thermosetting resin and all-service jacket manufactured from kraft paper, reinforcing scrim, aluminium foil, and vinyl film.

1. Thermal Conductivity: 0.038W/mK at 20 deg. C (68 deg. F).
2. Density: 24kg/m3.

A140 FLEXIBLE ELASTOMERIC THERMAL INSULATION: Closed-cell, sponge- or expanded-rubber materials.

1. Adhesive: Solvent base, contact adhesive as recommended by insulation material manufacturer.

2. Ultraviolet-Protective Coating: As recommended by insulation material manufacturer.
3. Thermal Conductivity: 0.038W/mK at 20 deg. C (68 deg F).
4. Density: 65 to 80 kg/m3.
5. Water Vapour Permeability: 0.15 perm-inch.
6. Noise Reduction: Up to 27 ΔL for 20mm thick insulation.

A150 CALCIUM SILICATE INSULATION: Flat-, curved-, and grooved-block sections of noncombustible, inorganic, hydrous calcium silicate with a nonasbestos fibrous reinforcement. Average thermal conductivity shall not exceed 0.053 W/mK. at 25 deg. C.

A155 ACOUSTIC DUCT LINING: 15 mm thick rigid or flexible fibreglass with minimum density of 24 kg/m3 faced with woven, strong, black durable glass tissue. Minimum sound absorption coefficient to be as follows:

| Thickness mm | NRC No. 6 Rating | Sound Absorption Coefficient at Frequencies in Cycles per Second | | | | | |
|---|---|---|---|---|---|---|---|
| | | 125 | 250 | 500 | 1000 | 2000 | 4000 |
| 15 | 0.53 | 0.12 | 0.46 | 0.42 | 0.62 | 0.75 | 0.77 |

A160 PRODUCT DATA: Identify thermal conductivity, thickness, and jackets (both factory and field applied, if any), for each type of product indicated. All insulation products or their shipping cartons to bear labels indicating that flame and smoke ratings do not exceed above specified requirements.

A165 SAMPLES: submit samples for each type of insulation and field-applied jacket. Identify each Sample, describing product and intended use. Submit 300-mm square sections of each sample material. Submit manufacturer's Color Charts: Show the full range of colors available for each type of field-applied finish material indicated.

A170 MATERIAL TEST REPORTS: submit material test reports from a qualified testing agency acceptable to Engineer, indicating, interpreting, and certifying test results for compliance of insulation materials, sealers, attachments, cements, and jackets with requirements indicated. Include dates of tests.

A180 INSULATION AND JACKETING MANUFACTURERS: to be supplied from one of the following:

Isover Saint Gobain (France)
Johns-Manville (U.S.A.)
Owens-Corning Fiberglas Corp. (U.S.A.)
or approved equal.

A191 FIELD-APPLIED ALUMINIUM JACKET: Deep corrugated embossed or smotth surface sheets manufactured from aluminium alloy complying with ASTM B 209M and having an integrally bonded moisture barrier over entire surface in contact with insulation. Corrugated type shall not be used outdoors.

1. Finish and Thickness: Stucco embossed finish, 0.8 mm unless otherwise noted.
2. Moisture Barrier: 0.025-mm thick, heat-bonded polyethylene and kraft paper.

A195 BANDS: 19 mm wide, in one of the following materials compatible with jacket:

1. Stainless Steel: ASTM A 666, Type 304; 0.5 mm thick.
1. Galvanized Steel: 0.13 mm thick.
2. Aluminum: 0.18 mm thick.
3. Brass: 0.25 mm thick.
4. Nickel-Copper Alloy: 0.13 mm thick.

A196 WIRE: 2.0-mm, nickel-copper alloy; 1.6-mm, soft-annealed, stainless steel; or 1.6-mm, soft-annealed, galvanized steel.

A197 ADHESIVE-ATTACHED ANCHOR PINS AND SPEED WASHERS: Galvanized steel plate, pin, and washer manufactured for attachment to duct and plenum with adhesive. Pin length sufficient for insulation thickness indicated.

1. Adhesive: Recommended by the anchor pin manufacturer as appropriate for surface temperatures of ducts, plenums, and breechings; and to achieve a holding capacity of 45 kg for direct pull perpendicular to the adhered surface.

A198 ADHESIVES:

1. Cloth: Adhesives for adhering, sizing, and finishing open-weave glass cloth shall be pigmented polyvinyl acetate emulsion and shall conform to the requirements of ASTM C 916, Type I.
2. Cellular Elastomer: Adhesive for cellular elastomer insulation shall be a solvent cutback chloroprene elastomer conforming to ASTM C 916, Type I, and shall be a type approved by the manufacturer of the cellular elastomer for the intended use.

A199 COATINGS:

1. Outdoor and Indoor Non-Vapor-Barrier Finishing: Coatings for outdoor and indoor non-vapor-barrier finishing of insulation surfaces shall be pigmented polymer emulsion recommended by the insulation-material manufacturer for the surface to be coated and shall be applied to the specified dry-film thickness.
2. Cellular Elastomer Insulation: Finish coating for cellular elastomer insulation shall be a polyvinylchloride lacquer approved by the manufacturer of the cellular elastomer for the intended use.
3. Coating Color: Coating color shall conform to color code specified or as directed by the Engineer.

A200 VAPOR RETARDERS MASTICS: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

561:P INSULATION

561:P1 PIPE INSULATION

INTERIOR INSULATION APPLICATION

P105 TYPE: CONDENSATE DRAIN PIPING.

1. Insulation Material: Flexible elastomeric.
2. Thickness: **[15mm]** Field-Appli**ed Jack**et: None.
3. Vapor Retarder Required: Yes.

P130 TYPE: REFRIGERANT SUCTION AND HOT-GAS PIPING.

1. Insulation Material: Flexible elastomeric.
2. Thickness: 25mm.
3. Field-Applied Jacket: None.

P140 TYPE: SERVICE: DIESEL-ENGINE EXHAUST.

1. Insulation Material: Calcium silicate.
2. Insulation Thickness: Pipe, all sizes: two layers, each layer 50 mm thick.
3. Field-Applied Jacket: Stainless steel.

EXTERIOR INSULATION APPLICATION

P180 TYPE: REFRIGERANT SUCTION

1. Insulation Material: Flexible elastomeric.
2. Thickness: 32mm.
3. Field-Applied Jacket: None.

P140 TYPE: SERVICE: DIESEL-ENGINE EXHAUST.

1. Insulation Material: Calcium silicate.
2. Insulation Thickness: Pipe, all sizes: two layers, each layer 50 mm thick.
3. Field-Applied Jacket: Stainless steel.

561:P3 EQUIPMENT INSULATION

P310 TYPE: INTERIOR TANK AND VESSEL INSULATION APPLICATION: DOMESTIC HOT-WATER STORAGE TANKS, NOT FACTORY INSULATED.

1. Insulation Material: glass fiber.
2. Insulation Thickness: 25mm
3. Field-Applied Jacket: Aluminium.
4. Aluminium Thickness: 0.8 mm
5. Vapour Retarder Required: No.

WORKMANSHIP

561:1 GENERALLY

1001 EXAMINE substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

1005 PROCEED with installation only after unsatisfactory conditions have been corrected.

1010 SURFACE PREPARATION: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

1015 APPLY insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

1020 USE ACCESSORIES compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

1025 APPLY MULTIPLE LAYERS of insulation with longitudinal and end seams staggered.

1030 SEAL JOINTS and seams with vapour-retarder mastic on insulation indicated to receive a vapour retarder.

1035 KEEP insulation materials dry during application and finishing.

1040 APPLY insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.

1045 APPLY insulation with the least number of joints practical.

1050 APPLY insulation over fittings and specialties, with continuous thermal and vapor-retarder integrity, unless otherwise indicated.

1055 HANGERS AND ANCHORS: Where vapour retarder is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retarder mastic. Apply insulation continuously through hangers and around anchor attachments.

1060 INSULATION TERMINATIONS: For insulation application where vapor retarders are indicated, seal ends with a compound recommended by the insulation material manufacturer to maintain vapor retarder.

1065 APPLY insulation with integral jackets as follows:

1. Pull jacket tight and smooth.
2. Joints and Seams: Cover with tape and vapor retarder as recommended by insulation material manufacturer to maintain vapor seal.
3. Vapour-Retarder Mastics: Where vapour retarders are indicated, apply mastic on seams and joints and at ends adjacent to duct flanges and fittings.

1070 Cut insulation according to manufacturer's written instructions to prevent compressing insulation to less than 75 percent of its nominal thickness.

1075 Install vapour-retarder mastic on ducts, plenums and equipment scheduled to receive vapour retarders.

1. Ducts with Vapour Retarders: Overlap insulation facing at seams and seal with vapor-retarder mastic and pressure-sensitive tape having same facing as insulation. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-retarder seal.
2. Ducts without Vapour Retarders: Overlap insulation facing at seams and secure with outward clinching staples and pressure-sensitive tape having same facing as insulation.

1080 ROOF PENETRATIONS: Apply insulation for interior applications to a point even with top of roof flashing.

1. Seal penetrations with vapor-retarder mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Seal insulation to roof flashing with vapor-retarder mastic.

1085 INTERIOR WALL AND PARTITION PENETRATIONS: Apply insulation continuously through walls and partitions, except fire-rated walls and partitions.

1090 FIRE-RATED WALL AND PARTITION PENETRATIONS: Terminate insulation at fire/smoke damper sleeves for fire-rated wall and partition penetrations.

1095 FLOOR PENETRATIONS: Terminate insulation at underside of floor assembly and at floor support at top of floor.

1. For insulation indicated to have vapor retarders, taper termination and seal insulation ends with vapor-retarder mastic.

## 561:2 PIPEWORK INSULATION

### FLEXIBLE ELASTOMERIC THERMAL INSULATION APPLICATION

2020 APPLY insulation to straight pipes and tubes as follows:

1. Follow manufacturer's written instructions for applying insulation.
2. Seal longitudinal seams and end joints with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

2025 APPLY insulation to flanges as follows:

1. Apply pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of sheet insulation of the same thickness as pipe insulation.
4. Secure insulation to flanges and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

2030 APPLY insulation to fittings and elbows as follows:

1. Apply mitered sections of pipe insulation.
2. Secure insulation materials and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

2035 APPLY insulation to valves and specialties as follows:

1. Apply preformed valve covers manufactured of the same material as pipe insulation and attached according to the manufacturer's written instructions.
2. Apply cut segments of pipe and sheet insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, fabricate removable sections of insulation arranged to allow access to stainer basket.
3. Apply insulation to flanges as specified for flange insulation application.
4. Secure insulation to valves and specialties and seal seams with manufacturer's recommended adhesive. Cement to avoid openings in insulation that will allow passage of air to the pipe surface.

CALCIUM SILICATE INSULATION APPLICATION

2050 APPLY insulation to straight pipes and tubes as follows:

1. Secure each layer of insulation to pipe with stainless-steel bands at 300-mm intervals and tighten without deforming insulation materials.
2. Apply two-layer insulation with joints tightly butted and staggered at least 75 mm. Secure inner layer with 1.6-mm, soft-annealed, stainless-steel wire spaced at 300-mm intervals. Secure outer layer with stainless-steel bands at 300-mm intervals.
3. Apply a skim coat of glass-fiber, hydraulic-setting cement to surface of installed insulation. When dry, apply flood coat of lagging adhesive and press on one layer of glass cloth or tape. Overlap edges at least 25 mm.

Apply finish coat of lagging adhesive over glass cloth or tape. Thin the finish coat to achieve smooth finish.

2055 APPLY insulation to flanges as follows:

1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of block insulation of the same material and thickness as pipe insulation.
4. Finish flange insulation the same as pipe insulation.

2060 APPLY insulation to fittings and elbows as follows:

1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded sections of insulation are not available, apply mitered sections of calcium silicate insulation. Secure insulation materials with stainless-steel wire.
3. Finish insulation of fittings the same as pipe insulation.

2065 APPLY insulation to valves and specialties as follows:

1. Apply mitered segments of calcium silicate insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
2. Apply insulation to flanges as specified for flange insulation application.
3. Finish valve and specialty insulation the same as pipe insulation.

2085 APPLY METAL JACKET where indicated, with 50-mm overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 300 mm o.c. and at end joints.

FINISHES

2101 GLASS-CLOTH JACKETED INSULATION: Paint insulation finished with glass-cloth jacket.

2105 FLEXIBLE ELASTOMERIC THERMAL INSULATION: After adhesive has fully cured, apply two coats of the insulation manufacturer's recommended protective coating.

2110 COLOUR: Final colour as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

PIPING SYSTEM APPLICATIONS

2115 ITEMS NOT INSULATED: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:

1. Flexible connectors.
2. Vibration-control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.
6. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

561:4 EQUIPMENT INSULATION

GENERAL:

4101 INSULATE THE FOLLOWING INDOOR EQUIPMENT:

1. Domestic hot-water storage tanks, not factory insulated.

4105 OMIT INSULATION FROM THE FOLLOWING:

1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

BLANKETS, BOARD, AND BLOCK APPLICATIONS FOR TANKS AND VESSELS

4201 SECURE insulation with adhesive and anchor pins and speed washers.

4205 APPLY ADHESIVES according to manufacturer's recommended coverage rates for 100 percent coverage of tank and vessel surfaces.

4215 GROOVE AND SCORE INSULATION MATERIALS to fit as closely as possible to the equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joint. Stagger end joints.

4220 PROTECT exposed corners with secured corner angles.

4225 INSTALL adhesive-attached anchor pins and speed washers on sides of tanks and vessels as follows:

1. Do not weld anchor pins to ASME-labeled pressure vessels.
2. On tank and vessel, 75 mm maximum from insulation end joints, and 400 mm o.c. in both directions.
3. Do not overcompress insulation during installation.
4. Cut and miter insulation segments to fit curved sides and dome heads of tanks and vessels.

4230 IMPALE insulation over anchor pins and attach speed washers.

4235 CUT excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4240 SECURE each layer of insulation with stainless-steel bands.

4245 STAGGER JOINTS between insulation layers at least 75 mm.

4250 APPLY insulation in removable segments on equipment access doors and other elements that require frequent removal for service.

4255 BEVEL AND SEAL insulation ends around manholes, handholes, ASME stamps, and nameplates.

4260 APPLY vapour-retarder mastic to open joints, breaks, and punctures for insulation indicated to receive vapour retarder.

FINISHES

4401 GLASS-CLOTH JACKETED INSULATION: Paint insulation finished with glass-cloth jacket.

4405 FLEXIBLE ELASTOMERIC THERMAL INSULATION: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

4410 COLOUR: Final colour as selected by Engineer. Vary first and second coats to allow visual inspection of the completed Work.

FIELD-APPLIED JACKET APPLICATION

4501 APPLY glass-cloth jacket where indicated, directly over bare insulation or insulation with factory-applied jackets.

1. Apply jacket smooth and tight to surface with 50-mm overlap at seams and joints.
2. Embed glass cloth between two 1.6-mm thick coats of jacket manufacturer's recommended adhesive.
3. Completely encapsulate insulation with jacket, leaving no exposed raw insulation.

4505 FOIL AND PAPER JACKETS: Apply foil and paper jackets where indicated.

1. Draw jacket material smooth and tight.
2. Apply lap or joint strips with the same material as jacket.
3. Secure jacket to insulation with manufacturer's recommended adhesive.
4. Apply jackets with 40-mm laps at longitudinal seams and 75-mm wide joint strips at end joints.
5. Seal openings, punctures, and breaks in vapor-retarder jackets and exposed insulation with vapor-retarder mastic.

4515 ALUMINIUM JACKETS: Secure jackets according to jacket manufacturer's written instructions.

FIELD QUALITY CONTROL

4601 INSPECTION: Engage a qualified inspection agency acceptable to Engineer, to perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

4605 INSPECTION: Perform the following field quality-control inspections, after installing insulation materials, jackets, and finishes, to determine compliance with requirements:

1. Inspect pumps and tanks randomly selected by Engineer.
2. Remove insulation and covers from two chilled-water pumps or one percent of chilled-water pumps, whichever is greater.
3. Remove insulation and covers from two small tanks or one percent of small tanks, whichever is greater.

4610 INSULATION APPLICATIONS will be considered defective if sample inspection reveals noncompliance with requirements. Remove defective Work and replace with new materials according to these Specifications.

4615 REINSTALL insulation and covers on pumps and tanks uncovered for inspection according to these Specifications.

# 57 TESTING, BALANCING AND ADJUSTING

## 571 TESTING, BALANCING AND ADJUSTING

### WORKMANSHIP

### 571:1 GENERALLY

1001 TESTS: conduct in the presence of the Engineer, as directed by him and to his satisfaction.

1051 TEST EQUIPMENT: provide all equipment, material, instruments, tools, power and connections required for tests and for balancing and adjusting operations.

1101 TEST DATA to be recorded and submitted in bound report form for review and approval as to adequacy of tests run and results obtained therefrom.

### 571:2 PRESSURE TESTS

2001 HYDROSTATICALLY TEST piping systems to ensure complete tightness under specified test pressure. Systems may be tested as a whole or in part to facilitate progress of work.

2051 TEST PRESSURE: no part of a piping system is to be tested to pressure less than j measured at highest point of system. Maintain for 24 hours, during which time there is to be no noticeable drop in pressure.

2101 PRECAUTIONS: apply test before connecting piping to equipment. Remove, disconnect or blank off any device which might be damaged by test pressure. Gate valves to be open but not completely backseated. End valves to be capped. On flanged piping, install temporary blank flanges and firmly anchor to accommodate developed end thrust. Piping that may be damaged by end thrust is to be properly anchored, especially at changes in direction. Release test pressure slowly to prevent damage.

2151 TEST PROCEDURE: plug and blank off all openings in system and fill slowly with water. Vent all entrapped air. Ensure water reaches all parts of system. Apply pressure with hand pump connected to discharge into system through globe valve, check valve and recently calibrated pressure gauge. When test pressure is reached close globe valve and monitor pressure variations.

2201 INSPECTION: with the system under pressure, inspect pipes and joints for leaks.

2251 DEFECTS: replace defective parts. No makeshift repairs, or application of repair compound will be permitted.

2301 REPEAT TESTS until completely tight system is obtained.

## 571:4 BALANCING AND ADJUSTING AIR DISTRIBUTION SYSTEMS

4001 REGULATE AND BALANCE systems to obtain required quantities of supply, return, exhaust and fresh air. Measure air quantities with velometer or anemometer.

4051 PRECAUTIONS: before operating system for balancing, ensure dampers and registers are open, filters are clean and free of air bypass, moving equipment is lubricated and all necessary inspection and maintenance work is done for proper and safe operation.

4101 AIR DISTRIBUTION PATTERN: set registers and grilles with adjustable bars at correct deflection, as determined from manufacturer's data, to produce required air distribution pattern in space without causing draughts.

4151 PRELIMINARY TEST RUN: perform to determine total air quantity delivered by fan at existing system static pressure. Measure air quantity at fan inlet and from each air outlet. Total air quantities measured at outlets to be within +/-5% of air quantity measured at fan.

4201 TOTAL AIR QUANTITY delivered is to be adjusted by regulating fan speed with adjustable motor sheave to obtain specified air quantity. If total air quantity cannot be obtained without exceeding speed range of sheave or available motor horsepower notify the Engineer before proceeding.

4202 TOTAL AIR QUANTITY: after this is obtained from fan, balance system for required distribution of air quantities.

4251 TEST OPERATING DEVICES such as automatic dampers, fire dampers, volume control dampers and splitter vanes for proper, smooth and quiet operation.

4301 TEST REPORTS to include duct layouts showing where readings were taken, readings of air quantities as measured for supply, return, exhaust and fresh air, static pressures, details of method of balancing and instruments used.

## 571:5 TESTING OF EQUIPMENT

5001 EQUIPMENT AND ACCESSORIES are not to be subjected to pressure in excess of prescribed test pressure noted in its nameplate data or manufacturer's published data.

5051 TESTS : carry out as required to test equipment for performance and proper functioning and to demonstrate, to the Engineer's satisfaction, that equipment meets design requirements.

5101 RETEST equipment if adjusted, repaired or replaced.

5151 DATA TO BE MEASURED to be those items given on the Schedule of Equipment and including the following: entering and leaving water temperatures, entering and leaving air dry bulb and wet bulb temperature, ambient dry bulb and wet bulb temperatures, air quantities, water quantities, pressure drops on air and water sides, suction and discharge pressures, electric motor horsepower or kilowatt input from measured voltage, current and power factor, sound levels.

## 571:7 TESTING AND ADJUSTMENT OF CONTROLS

7001 OPERATE CONTROLS AND INSTRUMENTS simultaneously with equipment or system they control and test for proper, accurate, dependable operation.

7051 CALIBRATE AND ADJUST to the Engineer's satisfaction.

## 571:8 SYSTEM PERFORMANCE TEST

8001 TEST SYSTEMS after they have been fully checked, balanced and adjusted and all equipment verified to meet design requirements and operating satisfactorily, to demonstrate to the Engineer's satisfaction that they operate as designed and as intended.

8051 DURATION OF TESTS: operate and test systems for an operating period of two consecutive 24 hour working days. Each operating period to be considered a trial test run. Minimum of four trial test run will be required. Should any repair or adjustment (other than normal running adjustments) be necessary, tests are to be considered void and recommenced after adjustment or repair is completed. Obtain signed time sheets from the Engineer for each day of test.

8101 TIME OF TESTS: systems which normally operate during certain seasons are to be tested during those seasons under actual and normal operating conditions.

8151 SCHEDULING OF TESTS: one month before date set for commencing tests, submit for approval six copies of test procedure with tests to be performed, method of testing, instruments to be used, points of measurement and method of calculation. Date for commencing tests to be subject to approval obtained at least 5 days before each trial test run.

8201 TEST RESULTS: provide six copies for approval. Include approved copies in the Instruction Manual.

8251 ACCEPTANCE CERTIFICATE to be drawn up in 3 copies when all tests are carried out to the Engineer's satisfaction. Certificate to be signed the Engineer and the Contractor and one copy handed to the Contractor.

## 571:9 BALANCING AGENCY

9051 REQUIREMENTS: obtain the services of a testing and balancing agency, specialised in this type work, to perform the balancing work required under this Section. The agency selected is not to have installed, fabricated or engineered any part of the system that the test and balancing work are to be performed on. In addition, the selected agency is not to be a subsidiary of, or be associated with persons having financial interests in the accessories, ductwork, controls, etc. undergoing these tests. The agency is to provide warranty certificate on receipt of balancing contract. All work by this agency is to be done under direct supervision of a registered heating and ventilating engineer employed by the agency which is to have at least 5 years experience as a company. All instruments used by this agency are to be accurately calibrated and maintained in good working order. If requested the tests are to be conducted in the presence of the Engineer. The agency is to include an extended warranty of 90 days, after completion of test and balance work, during which time the Engineer, at his discretion, may request a recheck, or resetting of any outlet, supply air fan, balance valve, pump or exhaust fan etc. as listed in test report. The agency is to provide technicians to assist the Engineer in making any tests he may require during this period of time. The agency is to submit 4 copies of compiled test data typed neatly and inserted in a loose leaf binder.

9101 STANDARDS: all work performed by the approved agency, is to be done in full accordance with minimum standards, as set forth in AABC N.S.F.M.I., Volume Two No. 12173 and as specified.

# 59 OTHER WORK IN CONNECTION WITH HEATING, VENTILATING AND AIR CONDITIONING

## 591 BUILDER'S WORK

### PRODUCTS

### 591:A GENERALLY

A105 BUILDER'S WORK in connection with Heating, Ventilating and Air Conditioning such as equipment bases, pads and supports, cutting and patching of walls and slabs for passage of pipes and ducts, repatching, fixing of pipe hangers and supports to structures, excavation and backfilling, scaffolding, rigging, hoisting, waterproofing, cleaning and painting are to be provided as specified under this Section.

A110 MATERIALS AND WORKMANSHIP are to conform to requirements included in other Divisions/Sections of the Specification, as applicable.

### 591:X ACCESSORIES

### 591:X1 SUNDRIES

X105 PIPE SLEEVES for pipes passing through walls, floors and roof to be galvanised steel pipe, two nominal pipe sizes larger than pipe passing through for bare pipes, and of sufficient size to permit pipe insulation to pass through for insulated pipes.

X110 ESCUTCHEON PLATES to be nickel plated, split ring type, sized to match pipe that it is to conceal. Plates for pipes passing through sleeves which extend above floor surfaces to be deep recessed type to conceal sleeve.

X115 FLASHING SLEEVES: coated cast iron, caulking type, size specifically to fit pipe; as per:

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or approved equal.

X120 HANGERS AND SUPPORTS FASTENERS: power driven masonry expansion bolts with steel threaded studs or internally threaded studs and couplings as required.

X125 ABOVE GROUND FUEL TANK LADDER: fabricated from 25 mm diameter galvanised steel pipe.

591:X2 EQUIPMENT BASES, PADS AND SUPPORTS

X205 BASES FOR ROTATING AND RECIPROCATING EQUIPMENT AT SLAB ON GRADE: unless otherwise indicated, provide reinforced concrete foundation bases carried, independently of the building structure, to solid ground or bedrock and isolated from surrounding slab with 50 mm thick highly compressible cork board and mastic joint sealant, to prevent transmission of equipment vibration.

X210 PADS FOR FLOOR/ROOF SLAB MOUNTED EQUIPMENT: unless otherwise indicated, provide reinforced concrete support pads of suitable plan size and sufficient thickness to absorb equipment vibration, and complying fully with equipment manufacturer's recommendations.

WORKMANSHIP

591:1 EXCAVATION

1001 EXCAVATE AND BACKFILL as necessary, including shoring, sheet piling, bracing, pumping, restoring and protection of persons and property.

1051 TRENCHES: avoid excessive length of open trench.

1101 TRENCHES FOR UNDERGROUND PIPES: to be of adequate width. Carry excavation 200 mm below pipe invert. Bed bottom of trench with clean dry sand and trim by hand to receive pipes. Dig bell-hole at each joint to allow for making up joint. After pipe is tested and accepted carefully backfill with selected clean earth.

1151 BACKFILL TRENCHES in 100 mm thick layers to 600 mm above pipe and in 300 mm layers thereafter. Tamp each layer carefully and thoroughly before placing next layer. Exercise care not to damage or misalign pipes.

1201 UNDERGROUND FUEL TANK: place in pit so that top of tank is at least 600 mm below finished grade and tank is not closer than 3 m to any building. Slope of pit side walls to be 45 degrees.

1202 UNDERGROUND FUEL TANK: bed bottom of pit with minimum 150 mm thick layer of clean, dry, well compacted, evenly distributed sand, free from boulders, stones, cinder or organic material. Tank to rest uniformly on bed to prevent uneven settling or undue stresses on tank walls. Backfill with same quality sand to minimum 300 mm above top of tank and with clean tamped earth for remainder of excavation.

1203 UNDERGROUND FUEL TANK: where tank floatation can occur provide concrete ballast pad under tank and fix tank to pad with anchor bolts hooked around pad reinforcement and bolted to structural angle supports welded to tank. Separate tank from pad with minimum 150 mm thick sand layer.

1204 UNDERGROUND FUEL TANK: provide reinforced concrete manholes around tank access, fill connection and sounding line connection. Support manholes on structural steel channel frames welded to tank and extend manholes to finished grade. Cover manholes with standard 600 x 600 mm cast iron roadway manhole covers and frames.

## 591:2 EQUIPMENT BASES, PADS AND SUPPORTS

2001 SHOP DRAWINGS: submit for approval showing dimensions, arrangements, construction details, vibration isolators, and sizes and locations of anchor bolts.

2151 VIBRATION ISOLATION MOUNTS: position in accordance with weight distribution of equipment and as recommended by manufacturer of equipment or mounts. Secure embedded mounts during concreting of base or pad.

2201 ALIGN AND LEVEL EQUIPMENT on bases, pads and supports over entire length and width; shim where necessary to facilitate levelling.

2251 CONCRETE BASES AND PADS: plaster and paint or finish as adjacent and surrounding flooring.

2252 CONCRETE BASES AND PADS: unless otherwise indicated or recommended, are to be 150 mm larger all around than equipment, of height to suit equipment and with top edge chamfered.

2301 ANCHOR BOLTS: set in oversized sleeves with washers and nuts at bottom. Bolts to project at least 6 mm above nuts when equipment is fixed to allow for shimming. Secure during concreting.

2351 SUSPENDED CRADLES AND WALL BRACKETS: test to sustain a load eight times actual operating weight of equipment supported.

## 591:3 HANGERS AND SUPPORTS

3001 FASTENERS: install in accordance with manufacturer's instructions.

3051 FASTENERS to penetrate 6 to 8 times shank diameter.

3101 EMBEDDED ATTACHMENTS: fix during concreting.

3151 TEST fasteners in ceilings and walls to sustain a load eight times operating weight of piping, ducting or equipment supported.

3201 ADDITIONAL FRAMING: provide where structure is inadequate to give suitable support. Design is to be approved.

## 591:4 PIPES PASSING THROUGH WALLS AND SLABS

4001 STRUCTURAL MEMBERS: do not cut without approval. Any approved cutting to be done only as directed.

4051 SLEEVES to be provided for all pipes passing through walls, floors and roofs. Locate before walls etc. are constructed and fasten securely to prevent displacement during construction. Plug ends during construction.

4052 SLEEVES to terminate flush with finished walls and ceilings and to project 20 mm above finished floors and 250 mm above rough concrete of roof.

4101 ESCUTCHEON PLATES to be provided for all exposed uninsulated pipes passing through walls, floors and ceilings.

## 591:5 JOINERY

5001 ACCESS DOORS: provide in false ceilings, walls or other construction to permit access to equipment, controls, etc. requiring periodic operation, inspection or maintenance.

## 591:6 WATERPROOFING

6001 OPENINGS IN EXTERNAL WALLS, ROOFS AND WALLS BELOW GROUND to be made watertight with sleeves, caulking, caulking fittings and flashings. Openings in external walls, particularly at and below ground level and in roofs to be plugged and caulked with oakum and lead between pipe and sleeve.

6051 WATERPROOFED CONSTRUCTION: method of installing work piercing waterproofed construction to be subject to review and approval.

6101 PIPES THROUGH ROOFS to be further waterproofed with 2 mm thick lead flashing fixed to pipe with flashing sleeve and extended under roof waterproofing membrane 300 mm all round.

## 591:7 CLEANING AND PAINTING

7001 CLEAN equipment, material, ductwork and piping etc. inside and outside by effective and approved methods to remove loose mill scale, blisters, sand, plaster, paint droppings, debris, dirt, oil, grease, labels and all foreign matter. Clean and brush work in stages as directed before painting or concealing.

7051 SURFACES TO BE PAINTED: clean with wire brush and cleaning solution. Do not apply paint to wet or damp surfaces.

7101 BLACK STEEL PIPING including flanges, bo, nuts, cast iron valves and accessories, valve wheels and all ferrous parts are to be painted with two coats of zinc chromate primer whether or not they are to be insulated. When bare or exposed to view, they are to be further painted with two coats of approved oil paint.

7151 PIPING run in trenches, shafts, underground or outdoors, including flanges, bolts, nuts, valves and all ferrous parts to be painted with two coats of zinc chromate primer and two coats of heavy bituminous solution paint.

7152 PIPING: when directed by the Engineer piping in machine room is to be painted to conform to ASME Colour Code. Alternatively stencil pipes to show service, size and direction of flow. Insulated pipes to be colour coded and stencilled over the external jacket.

7201 DUCTWORK: paint inside or outside with one coat dull black fire resistant paint where visible through registers and grilles.

7301 HANGERS AND SUPPORTS including clamps, rods, bolts, nuts etc. to be painted with two coats of zinc chromate primer and where exposed to view with two additional coats of approved oil paint.

7351 DAMAGED SURFACES of equipment to be restored to original condition by cleaning and painting as directed.

7401 UNFINISHED SURFACES to be painted as directed.

7451 HOT SURFACES to be painted with approved heat resistant paint.

7501 APPLY PAINT in strict accordance with manufacturer's instructions and recommendations.

# 592 ELECTRICAL WORK

## PRODUCTS

### 592:A GENERALLY

A105 ELECTRICAL WORK in connection with mechanical services, as described hereinafter, shall be executed as specified under this Section.

A110 STANDARDS: electrical equipment and accessories shall be manufactured in compliance with any of the following standards:

ANSI; NEMA; BS; VDE; DIN; IEC; UTE.

A115 MANUFACTURERS: obtain equipment and accessories from one of the following:

| | |
|---|---|
| GE/AEG | (Germany) |
| Cutler Hammer | (U.S.A.) |
| Alstom | (U.K./France) |
| General Electric | (U.S.A.) |
| Klockner Moeller | (Germany) |
| Merlin Gerin | (France) |
| Siemens | (Germany) |
| Square D | (U.S.A.) |
| EATON | (U.S.A.) |
| Schneider | (France) |

or approved equal.

### 592:H CONDUITS, WIRES AND CABLES

#### 592:H1 CONDUITS

H105 SIZE: minimum 20 mm unless otherwise specified.

H110 STEEL CONDUIT: welded, drawn, heavy gauge, to BS 4568 Part 1 intermediate metal conduit (IMC) to UL1242 and ANSI C80.6 for installations in hazardous, wet and outdoor areas and electrical metallic tubing (EMT) to UL797 and ANSI C.80.3 for indoor installations. Heavy gauge and IMC conduits shall be galvanised externally, galvanised or coated with organic corrosion resistant polymer internally and threaded both ends. EMT

conduits shall be non-threaded galvanised externally and protected internally with corrosion resistant enamel (Refer to electrical specification section 218).

H115 FITTINGS: threaded, galvanised or cadmium plated malleable iron.

H120 FITTINGS shall be specifically designed for size and type of conduit.

592:H2 WIRES AND CABLES

H205 POWER WIRES AND CABLES: 450/750 V grade, to IEC 60227-1, IEC 60227-2, IEC 60227-3, IEC 60227-4, IEC 60227-5 and IEC 60227-6 for wires and 600/1000 V grade, to IEC 60502-1, IEC 60502-2 and IEC 60502-4 for cables. Conductors to be annealed copper. Single conductor wires shall be insulated with moisture resistant flame retardant PVC/C. Single and multicore cables shall be insulated with XLPE or PVC/A compound as indicated in the motor control centre schedules or shown on the Drawings, with additional flame retardant PVC/ST2 sheath to IEC 60332-1-1 and IEC 60332-1-2 (Refer to electrical specification section 217).

H210 CONTROL WIRES AND CABLES: conductors shall be tinned annealed copper, minimum area 1.5 sq. mm. Insulation shall be moisture resistant flame retardant PVC/A compound. Wires shall be rated at 450/750 V to IEC 60227-1, IEC 60227-2, IEC 60227-3, IEC 60227-4, IEC 60227-5 and IEC 60227-6. Multicore cables for control and signalling to be PVC/A insulated copper conductors, copper wire or tape screened, flame retardant PVC/ST1 sheathed, rated at 600/1000 V to IEC 60502-1, IEC 60502-2 and IEC 60502-4 and IEC 60332-1-1 and IEC 60332-1-2 as indicated on the Drawings. Core identification is to be white printed numbers over black insulation. (Refer to electrical specification section 217).

H211 CONTROL WIRES AND CABLES: provide special heat resistant insulation or corrosion resistant sheath where required.

H215 ARMOURED CABLES: armour shall be single layer of galvanised steel wire under the PVC sheath for the multicore cables.

H220 CONNECTIONS TO MOTORS: single conductor wires pulled inside conduits, or multicore cables armoured or non armoured and fixed on cable trays or supports.

H225 SPECIAL CONDITIONS: where required high temperature resistant cables, silicone rubber, cross linked polyethylene, MICC, or approved equal, corrosion resistant sheath is to be provided.

## 592:J ELECTRIC MOTORS

J105 MOTORS shall be supplied by driven equipment manufacturer, to be as specified for equipment concerned and specifically supplied for available supply voltage and frequency.

J106 MOTORS one horsepower and under shall be single phase, and over one horsepower shall be three phase. Motors shall be totally enclosed, fan cooled type (TEFC), IC 411, protected against dust and water to IP54 for indoor installation, IP55 for outdoor installation and to IEC 60034 unless otherwise specified.

J107 MOTORS to have Class F insulation with maximum temperature rise not exceeding class B limits (80ºC) above average ambient temperature of 40 deg. C, unless otherwise specified.

J108 MOTORS that will operate outdoors are to have Class H insulation with maximum temperature rise not exceeding class B limits (80ºC) above average ambient temperature of 40 deg. C. unless otherwise specified.

J109 MOTORS operating in ambient temperatures exceeding 40 deg. C to be tropicalized and derated for satisfactory operation.

J110 MOTORS to be rated for continuous operation duty (S1) to IEC 60034. Where specified or recommended by the manufacturer, and approved by the Engineer, motors used for excessive intermittent periodic operation shall be of S3 duty to IEC 60034 and suitably designed for the expected number of starts.

J112 MOTORS FOR VARIABLE FREQUENCY OPERATION to be properly designed and derated for continuous operation with solid state variable frequency drives as specified here-in-after.

J115 POWER to be adequate to operate driven equipment without motor overload under all operating conditions and loads and throughout capacity range of equipment. Motor to be capable of delivering full rated output when operating at voltage deviating by 5% from rated voltage at rated frequency.

J120 STARTING AND TORQUE CHARACTERISTICS to be as required by driven equipment.

J125 SPEED to be as specified for equipment concerned.

J130 CONDUIT TERMINAL BOX ON MOTOR to be approved model for type of motor enclosure. Motor windings to be connected to terminals in terminal box at factory. One additional earthing terminal to be connected to motor frame.

J135 MOTOR BASE to be adjustable where motors are directly connected to driven equipment, unless otherwise specified. Motors connected to equipment through V-belt drive to have adjustable sliding base. Fractional horsepower motors to have slotted mounting holes in base.

J140 MOTOR PROTECTION: provide thermistors embedded in motor windings for thermal protection of motors over 50 HP.

## 592:X COMPONENTS AND ACCESSORIES

### 592:X1 STARTERS

X105 STARTERS for three phase motors to be magnetic or electronic solid state soft type as indicated in the motor control centre schedules or shown on the electrical drawings to automatically disconnect motor from power supply in case of supply failure, excessive voltage drop, over-current and lack of balance in phases. Overload trips to be provided for three phases.

X110 MOTOR DATA: obtain from equipment supplier before ordering any motor starter, or check motor nameplate for full load current rating and allowable temperature rise in order to select proper overload thermal element for motor starter.

X115 SHORT CIRCUIT PROTECTION DEVICE fitted to starter to be independent of controller and overload protection.

X120 CONTROL VOLTAGE for starters and control circuits is not to exceed 110 V.

X125 STEP DOWN CONTROL CIRCUIT TRANSFORMERS: two winding isolating type.

X130 CONTROL CIRCUIT PROTECTION: use high rupturing capacity fuses or circuit breakers.

X135 AUXILIARY SUPPLY for controls, other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

X140 CONTROL DEVICES on starters shall be as follows unless otherwise indicated or required by driven equipment: start stop push buttons, one red pilot light for "running", one green pilot light for "stopped" one amber pilot light for overload trip and one reset push button.

X145 STARTER TYPE A for single phase motors not exceeding 1/2 HP to be surface or flush mounted, manual two pole toggle type, for non reversing across the line starting, fitted with one overload element.

X150 STARTER TYPE B for three phase motors not exceeding 10 HP to be direct on line, non reversing, magnetic type, with manual reset, 3 pole overload relay and under voltage protection, unless otherwise required by local regulations.

X155 STARTER TYPE C for three phase motors over 10 HP, but not exceeding 50 HP, to be automatic star delta magnetic non reversing type, with 3 pole overload relay and under voltage protection, unless otherwise required by local regulations.

X160 STARTER TYPE D for three phase motors over 50 HP to be multiple step auto transformer non reversing magnetic type, with 3 pole overload relay, under voltage protection, unless otherwise required by local regulations. Auto transformer to be dry type, class F insulation, class B temperature rise over ambient temperature. Starter shall be suitable for 15 start per hour repeated after 2 hours for motors up to 200 HP and 3 starts per hour repeated after one hour for motors over 200 HP.

X162 ELECTRONIC SOLID STATE REDUCED VOLTAGE MOTOR SOFT STARTER: shall be UL listed, consisting of silicon controlled rectifier (SCR) based power section, digital logic board and paralleling bypass contactor to provide smooth, stepless acceleration for AC, 3-phase, 380 V, 60 HZ induction motors. The minimum peak inverse voltage rating of the SCR’s to be 1500 V. Contactor to be rated for full voltage across the line motor starting duty. Starter enclosure to be NEMA MG type 12 for indoor installation and type 3R for installations in wet and outdoor areas and provided with necessary ventilation fans. Where shown on the Drawings or indicated in the motor centre schedules, starter shall be incorporated within motor control centre. The starter shall provide the following protections and adjustments:

Adjustable electronic overload

Overheat protection for the starter

Phase sequence protection

Phase loss/unbalance protection

Undervoltage protection

Ramp time

Initial torque

Start current limit

Motor full load current

Starter to comprise moulded case motor circuit protector (with magnetic trip only) for short circuit protection. Starter shall be rated for 125% of the continuous current rating of the motor. Short circuit rating of start shall be at least 110% of the short circuit level at starter location, or as shown on the electrical drawings or indicated in the motor control centre schedules. Soft starters for pumps to comprise smooth soft stop facility for linear voltage deceleration with adjustable deceleration time.

X165 INDIVIDUALLY MOUNTED STARTERS to be totally enclosed in sheet steel enclosure with baked enamel finish. Design is to suit location and application. It is to be impossible to open enclosure door unless isolator is in open position.

X170 NAMEPLATES: starters and controls to have engraved nameplates identifying system or defining its function.

X175 CONTACTORS are to comply with IEC 60947-4, all parts, utilisation category AC3, and/or UL Standard 1008, and be 3-phase, 4-pole, magnetic type, 600 V rating, capable of interrupting at least ten times rated current inductive or non-inductive loads under normal service conditions and are to have replaceable main arcing contacts and arc quenching devices. Contactors are to withstand, without welding or burning of contacts, an inrush current of 20 times normal rating for 4 seconds upon closing and are to be capable of closing on the heaviest short-circuit of the system and withstand the short-circuit for period required by upstream short-circuit protective device to operate. Three N.O. and three N.C. spare contacts are to be provided on each contactor.

X180 STARTER CO-ORDINATION: motor starter devices shall be of type 2 co-ordination to IEC 60947-4-1.

## 592:X2 SWITCH DISCONNECTORS

X205 SWITCH DISCONNECTORS: non fusible, single throw type, with AC-23 utilisation category to IEC 60947-3 for AC motors, housed in separate metallic enclosure, with arc quenching devices on each pole capable of interrupting at least six times its rated current. They are to simultaneously interrupt power supply to all line conductors, any neutral and control circuits.

X206 SWITCH DISCONNECTORS for single phase fractional horsepower motors to be single pole, dolly operated type, rated 15/20 A at 250 V AC, quick make, quick break, with silver alloy contacts, flush or surface mounted to suit application.

X210 OPERATING MECHANISM to be quick make quick break type, with external operating handle mechanically interlocked with enclosure cover to necessitate disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.

X215 ENCLOSURE to be general purpose type, unless otherwise indicated or required, with provision for locking operating handle in OPEN and CLOSED positions.

X216 ENCLOSURES where indicated or required by location to be weatherproof totally sealed water and dust proof type.

## 592:X3 COMBINATION STARTERS SWITCH DISCONNECTORS

X305 COMPONENTS to comprise magnetic starter, switch disconnector and short circuit protection devices required by the Standards, in approved sheet metal enclosure to suit application.

X310 SWITCH DISCONNECTOR OPERATING MECHANISM: quick make, quick break, with external operating handle mechanically interlocked with enclosure cover necessitating disconnecting switch to be in OFF position for access to inside of enclosure. Means are to be provided for by passing interlocks. Position of isolating switch to be clearly indicated on cover.

X315 SHORT CIRCUIT PROTECTION GEAR shall be moulded case circuit breakers of appropriate current interrupting capacity.

X320 OPERATION OF CIRCUIT BREAKER to be possible from outside of enclosure. Position of breaker ON/OFF/TRIPPED to be clearly indicated by position of handle.

## 592:X4 PUSH BUTTONS

X405 PUSH BUTTONS to be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads to be colour coded and STOP button to be protected. Push buttons controlling one piece of equipment to be housed in separate enclosure.

## 592:X5 RELAYS

X505 RELAYS to be multipole with normally open or normally closed contacts, electrically operated at 110 V maximum, and magnetically held. Contacts to be double break, silvered type, interchangeable from normally open to normally closed without additional parts. Relays are to be rated at 10 A, 600 V.

## 592:X6 CIRCUIT BREAKERS

X605 CIRCUIT BREAKERS: thermal magnetic type for ratings up to 150 A frame and solid state electronic trip unit for ratings over 150 A frame, with moulded case, manually operated for normal switching functions and automatically operated under overload and short circuit conditions.

X606 CIRCUIT BREAKERS to give positive trip free operation on abnormal overloads, with quick make quick break contacts under both manual and automatic operation. Stationary and movable contacts to be non welding silver alloy adequately protected with effective and rapid arc interruption.

X607 MOTOR CIRCUIT PROTECTOR: moulded case, magnetic break type with adjustable instantaneous setting suitable for motor protection.

X608 MOULDED CASE SWITCH: similar to circuit breakers but without overload/short circuit protection. Short time rating of switches is to be not less than the short circuit current at switch location for 3 cycles. Switches are to have a suitable self-override instantaneous protection and to be in compliance with IEC 60947-3.

X610 BRANCH CIRCUIT BREAKERS to be 100 A minimum frame size, unless otherwise shown on the Drawings.

X615 MAIN CIRCUIT BREAKERS to be 150 A minimum frame size unless otherwise shown on the Drawings.

X616 CIRCUIT BREAKERS AND MOTOR CIRCUIT PROTECTORS are to be in compliance with IEC 60947-2, utilisation category B, sequence II (service capacity) for motor control centres and sequence III (ultimate capacity) for motor control panels and combination starters unless otherwise indicated on the drawings.

X618 ELECTRONIC TRIP UNIT: circuit breaker electronic trip unit shall be provided with adjustable long time, short time and instantaneous current setting. In addition adjustable earth fault protection shall be provided on trip units for main incoming circuit breakers.

X625 MAIN INCOMING BREAKERS / SWITCHES to be equipped to provide earth fault phase failure and phase sequence protection through shunt trip coil. Earth fault detection and interruption to be time co-ordinated with those of main incoming breaker on main distribution board.

X630 MULTIPLE POLE BREAKERS to have single handle mechanism. Each pole to have inverse time delay thermal overcurrent trip element and magnetic instantaneous overcurrent trip element for simultaneous tripping of all poles.

X635 TRIP ELEMENTS to be ambient temperature compensated type.

## 592:X8 MOTOR CONTROL PANELS

X805 TYPE: wall mounted or unit mounted, lockable type, IP 42 for indoor installation.

X810 CONSTRUCTION: minimum 1.5 mm thick hot-dip galvanised steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally.

X815 PANELS INSTALLED OUTDOORS AND IN WET AREAS to have weatherproof totally sealed water and dustproof IP 55 enclosures.

X820 COMPONENTS: panels are to contain necessary breakers, starters, push button switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.

X825 LABELS: starters, switches, electrical devices and accessories to be clearly labelled in English as to function and number. Labels to be permanently fixed under each component.

X830 SCHEMATIC AND WIRING DIAGRAMS to be mounted in permanent approved manner on inside of panel door. Diagrams are to show each component cross referenced with component labels.

## 592:X9 CONTROL SWITCHES

X905 FLOAT SWITCH: level operated, heavy duty, bracket mounted type, suitable for application in open tanks, complete with 178 mm spun copper float, brass rod, two stops, floor mounting stand, lever and counterweight. Switch to have oil tight and dust tight enclosure and 2 pole double throw silver contacts that open on liquid rise:

Man: Square D Company
Ref: Type BW 3

or approved equal.

X910 PRESSURE SWITCH: industrial, heavy duty, bellows actuated type, suitable for water service, with contacts to close on falling pressure. Range to be 0.1 to 8 kg/cm2. Switch to be good for 1720 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts and setting adjustment:

Man: Square D Company
Ref: Type ACW-1

or approved equal.

X915 LOW SUCTION PRESSURE SWITCH: industrial, sensitive, low range, diaphragm actuated type, suitable for water service, with range of 2 to 20 kPa of falling pressure, preset at factory to 3 kPa. Switch to be good for 690 kPa operating pressure and to have 6 mm pipe tap bottom connection. It is to have oil tight and dust tight enclosure, single pole double throw contacts, range adjustment knob, sealing cap and range locking nut:

Man: Square D Company

Ref: Type AMW-1

or approved equal.

WORKMANSHIP

592:1 GENERALLY

1001 GENERALLY: work is to conform to the requirements of Division 2 Electrical Installations.

1051 SHOP AND INSTALLATION DRAWINGS to be submitted for approval prior to ordering materials and equipment. Drawings to include the following:

complete technical data on all motor starters, motor protection relays, sensing units, control accessories, etc.

instructional details of equipment, particularly motor control centers and panels

wiring diagrams of all power and control circuits

installation details of motor control centres and panels and of control and sensing accessories

exact routing of power and control cables, wiring and conduits

feeder termination details at motor control centres, starters, motors, isolating switches, control and sensing accessories etc.

592:2 WIRING AND CONDUITS

2001 POWER AND CONTROL WIRING: run in conduit unless otherwise specified.

2051 POWER AND CONTROL WIRING: run in separate conduits.

2101 RIGID CONDUITS are not to terminate in nor be fastened to a motor frame or base.

2151 FLEXIBLE CONDUITS to be used at motor connections. Allow sufficient slack to permit motor to slide over adjustable length of motor base.

2152 FLEXIBLE CONDUITS: length and radius to be sufficient to permit bending of feeder cables without damage to conductor or its insulation.

2153 FLEXIBLE CONDUITS: do not use in place of rigid conduit except at motor connections, unless otherwise specified.

2201 SUPPORT CONDUIT with conduit supports in an adequate approved manner.

2251 CONDUITS are not to cross pipe or vent shafts, ducts or openings. They are to be run a minimum 100 mm away from pipes of non-electrical services.

2252 CONDUITS: install so that moisture can drain to lowest point. Provide screw plug at all low points for draining.

## 592:3 CONTROL CIRCUITS

3001 SUBMIT FOR APPROVAL detailed control wiring diagrams and a list of control equipment with descriptive literature. Free hand field wiring diagrams or sketches will not be accepted.

3051 ARRANGE CIRCUITS to satisfy operating requirements specified for various equipment driven by electricity and other requirements pertaining to proper functioning and operation of equipment.

3101 PROTECT CIRCUITS with high rupturing capacity fuses or circuit breakers. Auxiliary supply for controls, other than from main power circuit, to be effectively isolated by auxiliary contacts on main isolator.

## 592:4 EARTHING

4001 EARTH MOTORS by connecting green insulated conductor from earthing bushing in starter to motor frame. Run earth conductor together with circuit wiring and terminate in motor terminal box, provided earth terminal in box is connected to motor frame. If this is not feasible, extend earth conductor through insulated bushed opening in terminal box and connect to motor base.

4051 EARTH EQUIPMENT by connecting non-current carrying metal parts of system to earth source. Non-current carrying metal parts include conduits, cable trays, outlet boxes, cabinets, enclosures, doors, grilles, and barriers protecting or shielding electrical equipment from direct access.

592:5 EQUIPMENT

5001 STARTERS: fix detailed wiring diagram inside enclosure cover to clearly indicate circuits.

5002 STARTERS: identify control and power wires either by distinctive coloured insulation, engraved tags or other approved method.

5051 CIRCUIT BREAKERS: co-ordinate earth fault detection and interruption with those of main incoming breaker on main distribution panel.

5101 PRESSURE SWITCHES: test after installation to ensure dependable operation and correct setting.

5151 LOW SUCTION PRESSURE SWITCHES: test after installation to ensure dependable operation and correct setting.