REPUBLIC OF LEBANON

COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

EXPANSION AND UPGRADE OF AL-GHADIR WASTEWATER TREATMENT PLANT PROJECT – PHASE I: DESIGN, BUILD AND OPERATE, INCLUDING TWO NEW SEA OUTFALLS AND INSPECTION & ASSESSMENT OF EXISTING SEA OUTFALLS

Fund: Islamic Development Bank (IsDB)

Tender Documents

Part 2 – Employer's Requirements

August 2026

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Founded 1956

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SECTION VII – EMPLOYER'S REQUIREMENTS

PART A: GENERAL REQUIREMENTS FOR WWTP

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A.1. GENERAL REQUIREMENTS FOR WWTP

A.1.1. Reference to Other Chapters

Throughout the Specifications and Prices Schedules, references are occasionally made to other Chapters. All such references are intended solely for the convenience of those using the documents, and the absence of a reference in no manner excludes the application of every other chapter in the Specifications which may, in the opinion of the Engineer, have any bearing upon the point in question, the intention being that the Contract Documents shall be read and applied as a whole.

A.1.2. Existing Facilities Within the Site of Works

The existing plant occupies approximately 21,500 m2, with public land (31,300 m2) located at the south-west of a reclaimed land, acquired by CDR and allocated to the "Expansion and Upgrade of Al-Ghadir Wastewater Treatment Plant Project – Phase I: Design, Build and Operate, Including Two Sea Outfalls and Inspection & Assessment of Existing Sea Outfalls". The area of the reclaimed land is approximately 131,850 m2; however, due to the setback imposed by Beirut Airport Authorities and the existence of archaeological ancient wall at site, the constructable area is reduced down to 112,255 m2. In addition, the reclaimed land is distant of 250 m, minimum, from the existing WWTP land including the coastal highway. Thus, an access road will be required to connect the existing and new WWTP parts at the appropriate locations, including a bridge to cross over the highway.

The height of the buildings and tanks shall be subject to the regulation set by the General Directorate of Urban Planning and Beirut Airport Authorities; the height envelop as per current regulation is shown on the tender drawings. Upon the award of the contract, the contractor must verify any update of the regulation and implement it in his design. The contractor must take extra caution during the excavation and report any finding of archeological monuments to CDR, Engineer and General Directorate of Antiquities.

The Contractor shall note that the reclaimed land is a backfill area overlaying loose to medium dense seabed sediments, which is still active by a third party till a predefined fill level. Therefore, soil treatment is needed including a deep dynamic compaction, before starting any construction or further backfilling works to reach the levels adopted in the design.

The existing Al-Ghadir Wastewater Treatment Plant (GWWTP) consists of Preliminary Treatment Facility and sea outfalls. It has been subject in 2024 to critical repair works financed by UNICEF. This does not relief the contractor from making his own assessment of the existing facilities and equipment prior to submitting his offer.

The plant consists of preliminary treatment works including:

- Inlet manhole with overflow/bypass of the incoming wastewater from the sewage networks and the tanker tracks;
- Lifting station consisting of seven (7) Archimedean screw pumps complete with their motor and control panel. The capacity of each pump is 440 L/s at 5.36 m head (37 kW);
- Screening consisting of five (5) channels each containing One (1) stainless steel coarse screen, 40 mm opening. Channel width 1.4 m, channel depth 1.45 m. The system is complete with isolation stop logs, belt conveyors and screw compactors. The control panel of the screen are located besides the screens' channels;
- Grit and scum removal system consisting of 4 grit removal tanks complete with scrapers, skimmers and grit pumps. Each tank has approximately 6.4 m width and 7.5 m overall depth. In addition to two grit classifiers and a blower room;
- Sea outfall pumping station consisting of wet well and dry well. It includes three (3) vertically installed pumps (2 duty, 1 standby) complete with their piping, fittings and connection for one future additional pump. Each pump capacity is 1.32 m^3/s at 11.12 m head (250 kW), complete with VFD;

- Main sea outfall for the discharge of the treated wastewater to the sea via the pumping station. It consists of DN1200 smooth steel pipe, approximately 2.5 km long;
- Emergency sea outfall for the discharge of untreated wastewater consisting of DN1500 smooth steel pipe, approximately 500 m long;
- Bypass/overflow facilities;
- Electrical supply system: The wastewater treatment plant is supplied from the EDL power grid via a loop connection on a 20kV medium-voltage line;

  A transformer substation equipped with medium-voltage cells and two 20kV/400V transformers, each with a power rating of 1,000kVA.

  Each transformer supplies a Main Distribution Board (MDB) installed in the transformer substation building.

  Transformer TR1 supplies the MDB/S1 and transformer TR2 supplies the MDB/S2.

  Each MDB is also powered in normal/emergency mode by three diesel generators connected in parallel on a common bus bar panel (TBB).

  From these Main Distribution Boards, various MCC panels and sub-panel board (SPB) are supplied, divided into the following main process phases (Refer to Part 5 – Section XIII / Appendices 8.2 to 8.7):

- MDB-S1: Main Distribution Board feeding the following:
  - MCC-LS (1) and MCC-LS (2): Lift Station (Screw Pumps).
  - MCC-BS: Bar Screens, Belt Conveyor and Screw Compactor
  - MCC-GS: Degritting Area. (Degritting Bridges, Grit Pumps, Cable Reels)
  - MCC-BR: Blower Room. (Air Blowers)
  - MCC-MPS: Main Pumping Station.
  - MCC-FP: Fuel Pumps.
  - SPB LS: For Lift Station.
  - SPB E
  - SPB BR: For Blower Room.
  - SPB GH: For Guard House.
  - SPB MP: For Pumping Station.
  - SPB LS: For Lift Station.
- MDB-S2: Main Distribution Board feeding the following:
  - VSD-01, VSD-02, VSD-03: Variable Speed Drives for Main Outfall Pumps.
  - SCADA System: Not functional.

In addition, the existing plant includes the following facilities:

- Laboratory: Located inside the main pumping station building, to be fully rehabilitated by others (UNICEF)
- Guard House: Located beside the Entrance, to be fully rehabilitated by others (UNICEF)
- Fence and gate, to be fully rehabilitated by others (UNICEF):
- Not safe damaged structures (Old Consultant building and old toilets rooms): They shall be demolished.
- The existing WWTP site contains various uncovered materials and equipment, useful or not in use, inadequately stockpiled in different locations.

A.1.3. Airport Regulations Compliance

Since the project works are located in the vicinity of Beirut Airport territories and facilities, the Contractor shall coordinate with the Airport Authorities. Lebanese Civil Aviation Authority and any other concerned authority, in order to confirm/update the regulations regarding the construction beside the Airport territories. The works design and implementation, to be undertaken by the Contractor, shall be strictly in compliance with the Airport regulations.

A.1.4. Non-disclosure of Information

The Contractor shall not without the consent in writing of the Employer disclose particulars of the Contract to any person or furnish or publish or permit to be furnished or published any information with regard to the Employer's business to any person save in so far as may be necessary for the due performance of the Contract and shall preserve strict confidence with regard to any information of a confidential or secret nature received from the Employer or the Engineer.

A.1.5. Adjoining Contracts

The contractor shall coordinate with the contractors of other ongoing or executed adjoining contracts, including but not limited to:

1) Construction and Operation of Al-Ghadir Sanitary Landfill (for the reclaimed land)
2) Critical Civil and Electro-Mechanical Rehabilitation of Al-Ghadir Pre-treatment WWTP in the existing site
3) Any other separate project related to Al-Ghadir WWTP and wastewater networks.

A.2. SITE OF WORKS

A.2.1. The Site

The Site shall be deemed to include all areas on which temporary and permanent Works are to be constructed, all other areas made available to the Contractor for the execution of the Works and all roads, tracks and footpaths whether private or public between the various parts of the Works.

A.2.2. Use of Land and Right of Way

A- The Contractor will, during the execution of the Works, have free and temporary use of working areas and accesses thereto, of the land shown in the Contract. The working areas will include space for the Contractor and the Engineer's offices, camps, stores, yards, constructional plant, temporary roads, parking areas and other temporary works. The Contractor's proposal for temporary works including overall layout plan in conformity with the Tender Documents shall be included in the Contractor proposal.

All use of land is subject to the Engineer's approval.

If the area of the sites is found to be inadequate, the Contractor shall make his own arrangements for all additional working areas in the vicinity of the Works or elsewhere for his site compound, offices, temporary accommodation and living facilities and for the offices of the Engineer's Representative.

B- Apart from transport to and from these areas the Contractor shall confine his operations under the Contract to these areas. Before entering any working sites, the Contractor shall give 30 days' notice to the Engineer in writing. Such notices shall be given for each occupation of the working sites.

C- Before entering any additional working sites (if any) the Contractor shall obtain and forward to the Engineer a copy of the written consent of the owner or occupier or Authority having charge of the land stating the purposes for which such land is to be used by the Contractor,

and defining the extent and periods of his occupation for which such consent is granted. Notwithstanding the requirements of such consent, additional working sites shall be protected by fences or barriers or other works as required by the Engineer. Wherever practicable a passage shall be maintained for vehicles and pedestrians along public roads and to all adjacent properties.

D- In the event of the Contractor making use of any special temporary way leave or additional accommodation acquired by him pursuant to the Conditions of Contract hereof or any trip for the disposal of surplus materials he shall obtain and forward to the Engineer a copy of the written consent of the owner and occupier or Authority having charge of the land in which such way leave, accommodation or tip is situated and shall make a record to be agreed by the Engineer of the condition of the surfaces of the land before entering thereon. The Contractor will not be permitted to occupy space in public roads or thoroughfares along the route of pipelines nor additional accommodation except with the written consent of the Engineer, whose consent will not be given unless the Contractor shall have first obtained the written consent of the Authority concerned and having charge of the road surface.

E- Temporary fences and barriers

Temporary fences and barriers shall be provided by the Contractor for the Working Sites.

Where there is no existing fencing or boundary walls the Contractor shall provide, erect before commencing the Works and maintain in good condition to the satisfaction of the Engineer temporary fencing in positions around the Contractor's areas shown on the Drawings or where directed by the Engineer. Except where otherwise specified fencing shall be close-boarded 2400 mm high for WWTP Sites or chain link for the remaining area; he shall provide lockable gates at each site entrance.

The Contractor shall remove all temporary fencing on completion of the Works, except for such fencing, or parts thereof as the Engineer may direct to be left in place in good condition for the Employer's use.

F- Temporary buildings etc, Classified as temporary works

Starting from the Commencement date, the Contractor shall have to bear the cost of management of all temporary buildings and/or works.

G- Notice boards

The Contractor shall manufacture 2 notice boards and erect them where directed by the Engineer. The notice boards shall be 2,00 x 3,00 m painted galvanized steel plates with support of steel pipes. The notice boards shall have the indication as instructed by the Engineer and be painted after fabrication on all surfaces.

The Contractor shall erect these boards on suitable supports in positions, as directed by the Engineer, within the Site, and/or outside in public land, with the approval of the concerned authority.

H- Advertising and publicity

Advertising will not be allowed on any hoarding whether temporary or permanent, or on any other part of the Works, except such as the Employer may require for his own purposes.

The Contractor shall obtain the permission of the Employer before publishing any article describing the Works. The Engineer's permission shall be obtained before any member of the public is allowed to inspect the Works. All visitors will be required to sign a form of indemnity.

A.2.3. Project Location

Al-Ghadir preliminary wastewater treatment facility is located at about 7 Km to the south of Beirut, at the direct proximity of the Beirut International Airport. The approximate stereographic coordinates at the center of the WWTP are X: -339421.906 and Y: - 36805.945 (Figure 2-1).



Figure 2-1: Aerial View of the Al-Ghadir Preliminary Treatment Facility and Project

The preliminary WWTP was considered suitably distant from residential areas at the time of construction. However, the proximity to the Airport has entailed certain limitations on extension due to limited land availability and to airport security issues. The design of the upgrade and expansion of the plant shall take into consideration such the sensitive of the area via the safe operation of the airport and pleasant landscaping.

The site is accessible via Ouzaii main coastal Highway that connects Beirut to the southern regions of the country. The proximity to the highway allows convenient access for construction, maintenance, and operational personnel. Additionally, the plant's location near the coastline facilitates the discharge of the treated wastewater into the sea through its sea outfall.

A.2.4. Special Conditions and Hazards

The Contractor shall observe the following conditions when drawing up his proposal for traffic access to the Sites and Working Sites and such proposals shall be submitted to the Engineer for his approval before implementation.

a) Location of access gates to suit the agreed traffic plan;
b) Restricted headroom due to flyovers, overhead cables and airport regulations. These constraints shall be confirmed / updated by coordination with Airport concerned authorities.
c) Restricted loading to existing services, manholes, etc;
d) Restrictions on height of temporary structures and/or the location of temporary offices due to the proximity of commercial/residential property;
e) Buildings in the locality particularly sensitive, due to their use or condition, to undue noise and vibration;

f) Access to private and public properties and buildings;
g) High voltage overhead cables;
h) Release of fumes, production of flames, inflammable and explosive gases in order not to jeopardize the operation of the aircraft flights.

A.2.5. Traffic Arrangements

The Contractor shall seek information on and comply with all requirements and recommendations of the police regarding traffic safety measures.

Plans for re-routing traffic along public streets during occupation of the Working Sites will be arranged by the contractor, and after the approval of the Engineer, with the appropriate Government Authorities which include the Traffic Police. Such arrangements include the acquisition of provisional Permits from the traffic authorities to occupy Working Sites. The Contractor shall not occupy any Working Sites without holding such Permits.

The Contractor shall provide, erect and maintain during his occupation all barriers and traffic signs as required by the Authorities or instructed by the Engineer. All signs must comply with standard international practice or as otherwise required by the traffic authorities. All written notices on signs shall be in both Arabic and English languages.

Since the access to the reclaimed land is via existing landfill site, the Contractor shall coordinate with the other contractors and operators of Costa Brava solid waste landfill site for easy and proper access including the new permanent road that will be constructed for the expansion of the GWWTP.

A.2.6. Amenities to be Preserved

The Contractor shall cause the least possible interference with existing amenities, whether natural or man-made. No trees shall be trimmed or felled except as authorised by the Engineer.

All lights provided by the Contractor shall be so placed or screened as not to interfere with the use of adjacent buildings, road users, traffic or signal lights, aircraft flights or other equipment of the Employer or other authority.

The Contractor shall store and place all materials, plant and appliances in such a manner as to prevent them causing injury or damage to persons or property and at a safe distance from roads, tracks and footpaths.

A.3. SITE CONDITIONS

A.3.1. General

A preliminary geotechnical investigation has been carried out for the WWTP, a copy of the geotechnical investigation works has been attached in the Tender, and the Contractor agreed that he was informed and he has analysed (such investigation).

The Contractor shall draw his own conclusion from the Geotechnical Investigation Report and the Employer recognizes no responsibility of any conclusion the Contractor may draw thereof.

A.3.2. Seismicity

The evaluation of the ground acceleration to use for the structural calculations will be done in accordance with local regulation and Eurocodes 8.

A.3.3. Climate

Beirut has a hot-summer Mediterranean climate characterized by mild days and nights. Autumn and spring are warm, winter is mild and rainy, and summer can be virtually rainless. August is considered the only really hot muggy month, with a monthly average high temperature of 32 °C, and January and

February are the coldest months, with a monthly average low temperature of 11 °C. The prevailing wind during the afternoon and evening is from the west; at night it reverses to offshore, blowing from the land out to sea.

The average annual rainfall is 893 millimetres, with the majority falling in winter, autumn and spring. Much of the autumn and spring rain falls in heavy downpours on a limited number of days, but in winter it is spread more evenly over a large number of days. Summer receives very little rainfall, if any. Snow is rare, except in the mountainous eastern suburbs, where snowfall is common due to the region's high altitudes.

A.3.4. Protection and Diversion of Existing Services

A- The Contractor shall be responsible for notifying the service authorities and the Engineer of his intention to expose the services and where so required by the service authority shall not commence operations until the service authority is represented on Site.

B- The Contractor shall excavate, protect until backfill and backfill in a manner so as not to damage the services.

C- As soon as a service is encountered in the excavation whether previously located or discovered during the course of excavation for the Permanent Works the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.

D- The Contractor shall be responsible for maintaining all such services including natural and artificial watercourses encountered by him in the construction of the Works and shall make good any damage caused directly or indirectly by his activities.

A.3.5. Protection of Antiquities and Fossils

A- As soon as antiquities or fossils are encountered during the course of any excavation, the Contractor shall forthwith call the attention of the Engineer and the appropriate service authority thereto.

B- Vulnerable parts of the discovered antiquities of fossils shall be protected by the Contractor as may be reasonable required by the Engineer.

C- No requirement of the Specifications regarding the disposal of material arising from site clearance or excavation shall override any provision in the Conditions of Contract as to the discovery of ownership, of fossils, coins, articles of value or antiquity of anything of geological or archaeological interest found on the Site.

A.4. SCOPE OF WORKS

A.4.1. Description

The services to be provided by the Contractor include, but are not limited to the following:

A- Design and additional studies

- The execution of additional studies (soil studies -in addition to preliminary geotechnical study given in Part 5, assessment of structures, water analyses, treatment tests, etc.) that he considers necessary.
- The topographical survey.
- Comprehensive site assessment report, to be submitted 2 weeks from site possession
- The preparation of a design report of the installations answering the programme fixed by the Employer’s Requirements.

- Documents forming the application for building permit, including the architect's drawings and layouts, and in particular the landscaping aspects, so that the Employer has only to file this application to the concerned authorities.
- The preparation of guide drawings, working design drawings for the civil engineering structures, reinforced concrete drawings and calculation notes, drawings and calculation notes for the roads, bridges and utilities networks, drawings and diagrams of equipment, erection and dismantling drawings, in compliance with the detailed design accepted by the Employer.

B- Implementation

Works to be carried out by the Contractor include but are not limited to the following:

a) Installation of the site and preparatory works, connection to telecoms, water, electricity and other networks.

b) Implementation of civil works in accordance with the accepted detailed design, including in particular:

- preliminary drillings and investigations for the existing facilities and networks, if necessary,
- soil treatment including deep dynamic compaction in the new WWTP site and related geotechnical investigations,
- geotechnical investigations for the new structures, (including the bridge crossing)
- earthworks and final backfilling, drainage (including removal and storage of materials and earth),
- special foundations, if necessary
- all shell construction (concrete, reinforced concrete, masonry, framework, roofing, sealing, cladding, etc.),
- all finishing and fitting works for the plant,
- fences, roads and utilities networks,
- access road connecting the existing and the new WWTP including a bridge permitting to cross over the highway.
- demolition of existing structures to be removed, if any, including pipes and the reuse or removal and dumping of the corresponding materials in locations authorized by local legislation, and levelling of the land thus freed,
- connection of the new installations with existing structures (pipes).

c) Implementation of the "electricity and electromechanical and hydromechanical equipment" section in conformity with the accepted detailed design, including the supply, testing and transportation on site of all necessary materials and equipment and their implementation or erection and adjustment, namely:

- hydraulic, mechanical and electrical treatment equipment, including driving equipment and control, monitoring, measurement, protection and safety devices
- miscellaneous equipment required for the proper operation and maintenance of the installations, (lighting, heating, telephone, etc.),
- the remote surveillance system, if any

d) The commissioning of the installation and performance of the tests defined in the Employer's requirements.

e) The provision of maintenance and operating manuals, as-built drawings of the structures and networks.

f) Supply of 2 years spare parts at handing over.

g) Services for the Employer and the Engineer, as defined below and/or in this tender documents.

h) All necessary works required to complete the construction of the WWTP.

C- Operation and Maintenance

a) The contractor shall be in charge of the operation of the new treatment plant, as specified in Part 2

A.4.2. Health and Safety

The Contractor shall submit a Health and Safety Plan and shall formulate and submit site safety regulations/guidelines, taking into consideration the proximity of the airport facilities.

The Contractor shall be responsible for the safety of all workmen and other persons entering the Works and shall, at his own expense (where not otherwise stated) and to the approval of the Engineer, take all measures necessary to ensure their safety. Reference in these respects is made to the Conditions of Contract, but in particular, such measures shall include, but are not limited to, the following:

A- Provision of proper safety and emergency regulation; fire, gas (if any) and electric shock prevention, stretchers and first aid boxes, together with rescue facilities generally, for each place of working.

B- Safe shoring of all excavations.

C- Provision of efficient safety helmets for all personnel including the Employer and the Engineer and each of their staff and any authorized visitors to the Site.

D- Safe control of water including provision of ample standby pumping plant.

E- Provision and maintenance of suitable lighting to provide adequate illumination of the Works with appropriate spares and standby equipment.

F- Provision of good and safe access to any part of the Works.

G- Provision of notices written in Arabic and English languages to be erected at points likely to be used by the public, which shall warn the public of the existence of the Works. These notices shall be in addition to any statutory requirements demanded of the Contractor.

The Contractor shall submit for the approval of the Engineer the detailed health and safety plan and the site safety regulations/guidelines. When the regulations/guidelines have been approved, and before the work is started, the Contractor shall distribute copies in English and Arabic languages to all his employees and to the Engineer.

The Contractor shall ensure that all his employees are fully conversant with the safety regulations/guidelines, emergency and rescue procedures, etc., and the Contractor shall enforce the rule that any employee committing a serious breach of such regulations shall be instantly dismissed and shall not be re-employed.

H- Personal protective equipment shall be available and used by operatives when appropriate, including: safety helmet, eye protection, ear protection, hand protection, foot protection portable gas instruments for use to access confined spaces.

A.4.3. Transportation of Materials and Equipment

A- The Contractor shall take all reasonable precautions to ensure that public streets and thoroughfares used by him either for the construction of the Works or for the transport of

plant, labour and materials are not made dirty as a result of such construction or transport and in the event of their becoming thus dirtied in the opinion of the Engineer the Contractor shall take all necessary and immediate steps to clean them.

B- Vehicles shall be thoroughly cleaned down before leaving the Sites and shall be so loaded that spillage therefore is prevented. Particular care shall be observed when disposing of slurry type material in a highly fluid condition which may additionally be contaminated with bentonite.

C- Each individual site must be kept clean during the work and must be thoroughly cleaned upon completion.

A.4.4. Safety in Sewers and at Sewage Works

A- The recommendations contained in the booklet « Safety in Sewers and at Sewage Works » published by the Institution of Civil Engineers London shall be adhered to in respect of all work in operational sewers and waste water treatment plants.

B- The Contractor shall make all necessary arrangements with the appropriate authority before entering in or working on existing sewers and associated works.

C- The Contractor shall ensure that sufficient resources of supervisory staff are readily available to carry out such continuous working at established levels of safety.

A.4.5. Sanitation

A- The Contractor shall maintain the Site in a hygienic condition and shall comply with the requirements of the Engineer. At least all the wastewater produced on the Site, should be reasonably treated.

B- The Contractor shall comply with the requirements stipulated in British standards.

A.4.6. Prevention of Noise and Disturbance

A- The Contractor shall in general comply with the recommendations of international standards.

B- The Contractor shall justify the details and arrangements of all plant before installation to ensure that suitable provisions are provided to reduce noise emission in built-up areas.

C- The Contractor shall take noise intensity readings as required by the Engineer and shall submit the results to the Engineer. The Contractor shall comply with measures required by the Engineer to keep noise and disturbance to the reasonable minimum.

A.4.7. Fire prevention

A- The Contractor shall make arrangements to the satisfaction of the Engineer for the protection of the Works and any Temporary Works and any adjacent property from fire and shall give the Fire Authority all facilities periodically to inspect the fire prevention arrangements.

B- Particular care must be exercised in connection with the operation of electric-arc welding equipment, oxy-acetylene cutting equipment and other processes involving the use of naked lights. Special arrangements will be necessary for the storage of highly flammable liquids on the Site.

C- The Contractor shall remove all rubbish and surplus material of a flammable nature and take such other steps as the Engineer may require but this shall not relieve the Contractor of any of his obligations under the Contract.

A.4.8. Work in the Vicinity of Operational Mechanical and Electrical Equipment

A- Any permanent fencing or other safeguards required to be erected around electrical equipment shall be completed as far as practicable before connection is made to the electricity supply. In so far as this is not practicable the Engineer may permit the use of temporary fencing or other safeguards.

B- Where work has to be carried out in proximity to operational mechanical and electrical equipment other than the Contractor's own plant, the Contractor shall put into operation a « Permit to Work » system to the approval of the Engineer.

A.5. GENERAL COORDINATION

The contractor shall co-ordinate his work with that of his sub-contractors and, if any of the other contractors at the site, and the other contractors implementing the other contracts adjoined to the "Expansion and Upgrade of Al-Ghadir WWTP" project mentioned in above section 1.4 to whatever extent may be necessary to complete the project in accordance with the program of works, the drawings and specifications and the requirements of the engineer.

A.5.1. Coordination with Beirut Airport Authorities

The coordinator shall specifically coordinate his work with the Lebanese Civil Aviation Authority and all the concerned authorities in Beirut Airport in order not to jeopardize or to have any negative impact on the aviation mannering and Beirut Airport Activities.

A.5.2. Employer's use of Contractor's Temporary Works

The Contractor shall during the progress of the Works allow the Employer, the Engineer and other contractors employed by the Employer in connection with the Works the use of his roads, scaffolding, constructional plant, other temporary works or services such as described in the present Section. The Contractor shall at every place of working provide proper drainage, lighting and ventilation for other contractors' erection work and for the Engineer's inspection of the Works. Except for those items entered in the Price Schedules, such assistance shall be included in the rates.

A.5.3. Assistance to the Engineer's Staff and to Other Contractors

The Contractor shall provide labour for attendance on the Engineer for operations connected with supervision of the Works in particular for topographical survey. The attendance and assistance to the Engineer and his staff shall be included in the rates.

A.5.4. Disposal of Surplus Excavated Materials

Surplus excavated material and debris arising from the Works shall be:

- dumped on agreed disposal sites at the expenses of the Contractor. In order to avoid unauthorized disposal, the Contractor shall arrange that each cartage contractor and lorry driver employed for the disposal of such materials is given written instructions as to the approved place where each load is to be tipped. The Contractor shall retain in his office copies of such instructions, together with a list of approved places to be used, for inspection at any time by the Engineer.
- The Contractor shall indemnify the Employer against any claims arising from unauthorized disposal of such materials.
- re-used on the site for the landscaping development; in this case, the Contractor Proposal shall justify the characteristics and volume of materials; should the Contractor Proposal not include such arrangements, the re-use shall not be allowed.

A.6. TENDER DRAWINGS SUPPLIED TO THE CONTRACTOR

The only drawings provided by the Employer to the Contractor are the drawings included in the Tender Documents – Part 4.

A.7. DOCUMENTS AND DRAWINGS TO BE CARRIED OUT BY THE CONTRACTOR

A.7.1. Design Report

Within 60 days after the Commencement date, the Contractor will submit to the review of the Engineer a Design Report. This report will be based on the Contractor Proposal; it will include the following documents:

- The description of the plant
- The detailed process calculations
- The hydraulic profile
- The entering and leaving flows (water, grease, grit, sludge, etc.) in terms of quantities and pollution loads
- The pre-sizing of the structures
- The sizing of the installed power
- Some sketches of architectural and landscaping details
- The single line power diagram
- The general organisation of the remote-control system
- A weekly general implementation program
- A weekly Contractor's Documents submittal program

A.7.2. General Provisions for Construction Drawings

A- As soon as the Engineer notifies comments on the Design Report, the drawings shall be issued by the Contractor for construction. Such drawings shall be deemed to be Construction Drawings, part of the Contractor's Documents pursuant to Clause 5.2 of the General Conditions of Contract.

B- The drawings issued by the Contractor for construction shall cover the new constructions and the extension/rehabilitation of the existing constructions and will include:

- The demolishing plan showing all structures, road and pipes to be demolished either for relocation or permanently
- Topographical survey including:
  - Surveyed ground levels and contour lines
  - Locations with levels and dimensions details of the existing buildings and other structures.
  - Locations with levels and dimensions details of the existing piping networks and related manholes.
  - The existing landscape components: Roads, tiles, plantations,
- The general layout drawings showing existing and proposed wastewater treatment structures, access road, bridge, internal roads, offices, recreational area, etc, in addition to the required rehabilitation works of the existing facilities.

- Soil treatment drawings including layouts, boundaries, details, levels for the deep dynamic compaction and for the geotechnical investigations to be done prior to start deep dynamic compaction.
- Geotechnical investigations drawings for the new structures. (including bridge crossing)
- The foundation drawings, including if any temporary works such as excavation drawings, etc.
- Design and structural calculations for civil works
- The civil works guide drawings
- The access road, including bridge, internal roads, pipes, utilities and networks drawings.
- Process Flow diagram
- Piping and Instrumentation Diagram
- Mechanical Arrangement Drawing

  Instruments arrangement and location

  - The single line diagram
  - Cables layout
  - The flow chart of the remote control
  - Architectural and landscaping drawings.
  - The additional drawings as required by the Engineer to develop in greater detail the construction required.

All these drawings shall be referred to hereinafter as Construction Drawings. A documents schedule including drawings schedule shall be submitted for approval.

These drawings will be submitted by the Contractor, in accordance with the Documents' submittal program, to the approval of the Engineer.

C- Shop reinforcing steel drawings, detail erection drawings, concrete placing (lift) drawings, formwork drawings and other detail drawings including mechanical and electrical shop drawings shall be prepared by the Contractor on the basis of the Construction Drawings; they will be given for information to the Engineer.

D- All drawings shall be in the English language, and all dimensions shall be in Metric system. Symbols shall be in accordance with approved Standards. All drawings submitted for approval shall conform to ISO paper sizes A0 to A4. Title block and numbering shall be approved by the Engineer.

E- The Permanent Works shall be executed in conformity with the Construction Drawings and other drawings approved by the Engineer.

A.7.3. Civil Works

A- Design calculations

The design calculations which may be presented under existing computer forms shall include in particular:

1) Title page:

- Calculation conditions;
- The values of the maximum stresses under normal and exceptional operating conditions and during handling, transport and erection;
- The main dimensional characteristics:

- The properties of the materials used;
- Bibliographical references used for the calculations.

2) In the text:

- The loads to which the supply is subjected and their origin;
- The forces transmitted to supplies and to the foundations;
- Stresses to which the equipment will be subjected under normal and exceptional operating conditions (including handling, transport and erection);
- The permitted safety factors;
- In general, any indications required for a proper understanding of the design of the supply;
- The output, power and characteristics of drive or control motors.
- The Engineer reserves the right, during the design period, to request the Contractor for any additional design calculations which he considers necessary.

3) Drawings

- In addition to the documents listed in clause 8.2, the Contractor shall prepare and deliver to the Engineer for information the drawings for:
  - The Temporary Works,
  - The performance of the Works as necessary for showing the construction methods,
  - The Drawings relevant to the Construction of:
    - Access roads;
    - Contractor's camp and facilities,
    - the detailed drawings of concrete reinforcement and calculation works, as well as bar bending and cutting list,
  - The as-built drawings of all Permanent Works constructed as required in Sub-Clause 6.7 of the Conditions of Particular Application (Part 3),
  - The other drawings necessary for the performance of each part of the Works in accordance with the Contract.
  - The Contractor shall perform also the necessary calculations in connection with the required drawings.

4) The drawings prepared by the Contractor will be established for cases of maximum load likely to occur during operation of the Permanent Works, and exceptional load situations which may occur during construction in compliance with the method of works.

5) The Contractor shall be responsible for assuring the adequacy of all parts of the works with respect to loading which might occur during construction and shall supply calculation notes and drawings for any necessary falsework, supports, strengthening as may be required by the Engineer.

6) The Contractor shall be responsible for the behaviour of the Permanent Works during the various phases of construction. He shall provide all equipment and accessories and all working arrangements necessary to limit stresses on the Works, so that stability of the structures is not threatened and so that stresses and deformation remain within acceptable limits.

7) In the context of the above-mentioned arrangements, the Contractor may be authorised by the Engineer to reinforce the design of the Permanent Works, provided

always that such authorisation shall not entitle the Contractor to any additional payment, either on account of the quantity or quality of the materials used in addition.

A.7.4. Mechanical Equipment Included in the Present Contract

a) General

The Contractor is responsible for the execution of documents (drawings, diagrams, design calculations, erection, etc.) for the different supplies.

A list of all drawings, diagrams and design calculations to be submitted to the Engineer shall be drawn up at the start of the Works in agreement with the Engineer. However, the Engineer reserves the right to request further details at a later stage in order to facilitate understanding of equipment functions.

b) Civil works guide drawings

The Contractor shall supply the following documents for the Engineer's approval:

1) Civil Works guide drawings showing the layout and overall dimensions of the equipment.
2) Drawing of recesses to be made in the concrete with the directions and values of stresses transmitted to the concrete by the equipment.
3) Drawings of built-in parts.

c) Overall and detail drawings of the equipment

The Contractor shall supply drawings for information of assemblies, parts of assemblies and large parts of the equipment to the Engineer for information.

These drawings, or where applicable their technical associated documents, shall include, in addition to production dimensions, flatness, straightness, horizontal and vertical tolerances, the values of assembly and operating clearance with the minimum and maximum acceptable deviations, the type and the properties of the materials used in the different parts, the weld categories and the types of non-destructive testing to be carried out on welds, the surface condition valued to be achieved for parts machined in accordance with ISO/R 468 standard.

Drawings, or, where applicable, their technical associated documents shall also include the weights of assemblies, parts of assemblies and detailed parts as well as the surface areas to be painted for large structures.

A.7.5. Submission and Approval

A- The Contractor shall submit in three (3) copies to the Engineer, for review, information or approval, all documents and drawings which he prepares under this Clause (except for "As-Built"). The Engineer will analyse all such designs and drawings, will appraise them as to whether they are reasonable and consistent with the Construction Drawings, will approve if requested and will order changes when deemed necessary.

The Contractor's documents and drawings shall be submitted in a sequence to facilitate the Engineer's study and scrutiny of the same, shall be completed in regard to all computations and data, and shall be traced on size 840 mm x 594 mm (A1-size) or 297 mm x 420 mm (A3-size) paper. The title of the drawings, the signature of the Contractor's representative, the date of preparation and the reference to Construction Drawings, if any, shall appear in the bottom right-hand corner of the drawing. Within twenty-one (21) days after submission of the drawings, the Engineer will advise the Contractor of his conclusions regarding the drawings.

B- When approval is requested, the Engineer's conclusions may be one of the following:

- "APPROVED""
- “APPROVED EXCEPT AS NOTED”

- "DISAPPROVED" (with relevant reasons determining rejection duly indicated).

Within seven (7) days of the return of documents and drawings marked "APPROVED" or "APPROVED EXCEPT AS NOTED", the Contractor shall present to the Engineer one reproducible copy of the drawings traced in ink and two (2) prints of the same. These drawings will have an indices +1, noted "Approved for Execution by the Engineer on [*date*]"

No drawing shall be considered valid unless signed by the Engineer. The approval by the Engineer of such drawings shall not relieve the Contractor of his obligations and responsibilities under the Contract.

Those marked "DISAPPROVED" shall be redone and submitted as new to the Engineer.

The Contractor shall not be entitled to a time extension based upon the rejection of designs or detail drawings, because such designs or detail drawings fail to conform to sound engineering principles, or to the Specifications.

All materials ordered or Works performed prior to approval of the relevant designs, shall be at the Contractor's risk.

The Contractor shall bring to the attention of the Engineer any variation to the Contract in the document submitted for approval.

When no approval is requested within twenty-one (21) days after submission of the drawings, the Engineer will notify his comments or requests. All materials ordered, or work performed, prior this notification shall be at the Contractor's risk.

A.7.6. Ownership of Drawings and Data

All the drawings, details, bill of materials and any other information or documents furnished by the Contractor shall become the property of the Employer and shall be non-returnable. The Employer will have the right to use this property.

Such information shall be given in paper copy and in digital format.

A.7.7. Design Criteria

Unless otherwise specified, the following figures will be used as design criteria.

a) Acceleration due to gravity: for any relevant calculation or evaluation will be: g = 9.81 m/s².
b) Unit weight:
   - Waste water: 10KN/m³
   - Clarified water: 10KN/m³
   - Sludge: 10,5KN/m³

For design purposes, the Contractor shall refer to Standard Practice Documents (SPD's), prepared by SIU for guidance of consultants. These documents set out generally accepted good practice for design of Water and Wastewater installations. The current list of related Standard Practice Documents is as follows:

SPD 2: Health and Safety Design

SPD 4: Mechanical, Electrical and Instrumentation Systems

SPD 8: Sewerage and Drainage Systems

SPD 9: Sewage Treatment

SPD 10: Sewage and Drainage Pumping Stations

A.8. LAYOUT OF WORKS AND SURVEYS

A.8.1. Reference Points, Lines and Levels

A- General setting out

At the beginning of the Works, the Contractor and the Engineer shall agree on the definition and general setting out of the structures to be built on the site, based on the general network established for the project.

Three points which shall be used as a reference basis in three dimensions (X, Y, Z) will be made available at site by the Engineer by the date of beginning of the work. These three points shall be handled over to the Contractor, which will accept them as references. The Contractor will provide a detailed table includes the coordinates of all the buildings corners.

Additional bench marks may be provided by the Contractor for triangulation reference.

The Contractor shall be responsible for the conservation of the related benchmarks during the entire duration of the construction and Operation Service Period.

The Engineer shall draw up a report to confirm completion of these operations in the field.

B- Complementary setting out

During the execution of the Works, the Contractor shall complete the general setting out by as many stakes, seats and gauges as may be necessary.

C- Reference points

At the beginning of erection of equipment, complementary reference points shall be placed by the Contractor. Position of lines and levels shall be defined by mutual agreement of all parties. In case of disagreement the Engineer shall decide.

D- Approval

The Engineer will draw up a report to confirm completion of these operations in the field.

A.8.2. Record of Site before Construction

The Contractor shall perform topographical survey of the site within 28days after the Commencement Date, prior to his first entry thereon, and agrees the surface topography and ground conditions of the site and the immediate surrounding areas to the extent considered necessary by either the Engineer or the Contractor. The agreed record shall include the condition of existing services and facilities, buildings, roads, boundary walls, fences and trees and also shall include photographs and spot levels as necessary and written descriptions of the site conditions.

All buildings and structures situated adjacent to the site or close enough to the works which the Engineer considers could be affected by the construction of the works are to be structurally surveyed both internally and externally and agreed with the Engineer prior to construction work commencing. The survey is to include photographs where appropriate.

The survey will be approved by the Engineer.

A.8.3. Rehabilitation Works Assessment

The contractor shall achieve his own assessment of the current condition of the existing structures and facilities located inside the existing WWTP site through appropriate site survey.

The related assessment provided in the tender documents shall be taken into consideration by the Contractor, which will be validated or revised.

The extension/rehabilitation works shall therefore be defined and incorporated in appropriate drawings and calculation notes based on the following:

- The general process design of the whole WWTP.
- The extension/rehabilitation works proposed and detailed in the tender documents
- The findings of the Contractor assessment to be achieved as part of the survey works.

The final extension/rehabilitation works that shall be adopted in the project construction shall be approved by the Engineer.

A.9. STANDARDS, CODES AND REGULATIONS

A.9.1. General

A- General Standard specifications and codes of the following listed authorities wherever cited herein are referred to by use of the abbreviations shown below. All materials and workmanship shall comply with requirements of applicable codes:

SN	Description	Abbreviation
1	British Standards Institution Linford Wood, Milton Keynes, MK14 6LE - UK	BS
2	AWWA 6666 W. Quincy Ave., Denver, CO 80235 – USA	AWWA
3	Deutsches Institute fuer Normung e.v D-1000 BERLIN 30, Burggrafen Str. 6 Germany	DIN
4	Fédération Européenne de la Manutention 80 boulevard A. Reyers B-1030 BRUXELLES – Belgique	FEM
5	Commission Electrotechnique Internationale 1 rue de Varembé Case Postale 56	CEI
6	International Standard Organisation 1, rue de Varembe Case Postale 56 CH1211 GENEVE 20 - Suisse	ISO
7	European Committee for Standardization 36 rue de Strassart 1050 Brussels, Belgium	EN
8	American Society for Testing and Materials 1916 Race Street PHILADELPHIA, PA 19103 – USA	ASTM
9	American Association of Stage Highway and Transportation Officials 444 North Capitol Street, mw WASHINGTON, DC20001 – USA	AASHTO
10	American Concrete Institute Box 19150 - Belford Station DETROIT, MI 48219 - USA	ASI
11	Bundesanstalt fuer Wasserbau D-7500 KARLSRUHE, Kussmaulstr. 17 Germany	BAW
12	Association Française de Normalisation Tour Europe - Cedex 7 92080 PARIS LA DEFENSE – France	AFNOR
13	American National Standards Institute, Inc. 10 East 40th Street NEW YORK, NY 10016 - USA	ANSI
14	American Petroleum Institute	API
15	American Welding Society 205 MW 7th Street MIAMI FLO 33125 - USA	AWS
16	United States Bureau of Reclamation Engineering and Research Center Code 922 Post Office Box 25007 Denver Federal Center DENVER, Colorado 80225 - USA	USBR
17	The Institution of Civil Engineers Publication Thomas Telford Ltd. 1 Heron Quay, LONDON E148XF - UK	ICE
18	Eurocode 2, rue Bréderole B-1000 BRUXELLES – Belgique	

B- The following particular Standards will be used:

EN 12255, part 1 to 16: Wastewater treatment plants

EN 752, part 1 to 7: Drain and sewer systems outside buildings

EN 809: Pumps and pump unit for liquids- Common safety requirements

EN: 1085: Wastewater treatment- Vocabulary

A.9.2. Standards to be on Site

The Contractor shall obtain and keep on Site at least one soft copy of each concerned standard which is referred to in the Tender Documents. One soft copy shall be also at the disposal of the Engineer's Representative.

A.9.3. Applicable Standards

A- Unless otherwise specified, the Standard to apply will be as follows:

- Civil works and process: European Standards EN
- Mechanical works: DIN
- Electrical works: IEC (in addition to EAC requirements)
- Handling equipment: FEM
- Road: AASHTO

B- Except if otherwise specified, where such standards are mentioned, the latest revision or edition on the Reference Date shall apply.

C- When the Contract Documents contain particular specification or more restrictive specification than required in Standards and Codes listed above, the Contract Documents will always prevail.

D- In case of lack of precise requirements in the Specifications and even if no reference to any standard listed in Sub-Clause hereof, these standards shall be used as a reference.

A.9.4. Standards other than those Specified

A- Where requirements are specified by reference to a standard which has its origin in one country, it is not the intention to restrict the requirements solely to that standard and that country. The Contractor may propose to the Engineer an equivalent standard other than that specified, in which case he shall submit the proposed standard and all other information required by Section 14 (Approval of Materials and Equipment), and shall submit written proof that his proposed standard is equivalent in all significant respects to the standard specified. All submissions shall be made in English language.

B- If required, the Contractor shall supply a copy of these standards and regulations in English language.

A.10. WATER CONTROL

A- Without prejudice to other stipulations in the Contract, all constraints related to the presence of or risks caused by water, all additional work which may prove necessary on this account, all damage caused by water, all pumping in all structures not mentioned in the Contract which the Contractor may find he has to build for water control purposes shall be at the expense of the Contractor.

B- Without prejudice or other stipulations in the Contract, the Contractor shall be responsible for all damage caused to the foundations of the structure or any part of the Works and occasioned by floods, surface water or runoff, or by failure of any part of the diversion or protection

works carried out by the Contractor. Any repairs that are necessary will be carried out at his own expense.

C- Before any works are begun, the Contractor shall submit to the Engineer's approval the methods and arrangements he proposes to apply in order to protect the Works, unless these are imposed by the design incorporated in the Contract. Such Engineer's approval shall not relieve the Contractor of his obligations and responsibilities.

A.11. DEWATERING OF FOUNDATIONS

A- The Contractor shall provide, install, maintain and operate all pumping and other equipment for dewatering for all parts of the Site where this is necessary, and for as long as required for implementation of the works.

B- The dewatering facilities shall be such as to avoid any loss of fine materials, and shall ensure stability of the excavation works and adjacent buildings and facilities.

C- Water removed from the excavations must not be allowed to cause nuisance or damage to traffic or any public or private property or service.

D- All costs relevant to the present section are deemed to have been spread over the rates indicated in the Price Schedules.

A.12. SURVEYING EQUIPMENT

A- The Contractor shall provide for the use of the Employer and the Engineer on Site for every-day surveying the following normal accuracy instruments:

- 1 High-End Surveying GPS equipment
- level with tripod,
- staff gauges,
- chains or steel tapes,
- all other equipment necessary for the day-to-day surveying,
- 1 paint thickness controller,
- 1 concrete sclerometer.

B- All equipment supplied to the Engineer under this clause shall remain property of the Contractor on completion of the work.

C- All survey equipment for the use of the Employer and the Engineer on Site shall be maintained in good order by the Contractor.

D- All costs relevant to the present paragraph are deemed to have been spread over the rates indicated in the Price Schedules.

A.13. QUALITY OF MATERIALS

A.13.1. Manufactured Materials

A- All materials, fixtures, fittings, and supplies furnished under the Contract shall be new and unused, of standard first-grade quality and of the best workmanship and design. No inferior or low-grade materials, supplies or articles will be either approved or accepted, and all work of assembly and construction shall be done in a first-class and workmanlike manner.

B- In asking for prices on materials intended for delivery to the site and incorporation in the Works under any portion of these Specifications, the Contractor shall provide the manufacturer or supplier with complete information as may, in any case, be necessary to

secure compliance with this Clause and, in every case, he shall quote this Clause in full to each such manufacturer or supplier.

A.13.2. Quarried Materials

The Contractor shall be responsible for investigating and obtaining riprap stones, rockfill, filters and transitions and aggregates for concrete and other purposes. The Contractor shall develop such investigations that he may require to meet the Contract requirements.

A.13.3. Cement

The Contractor shall, within 28 calendar days after the Commencement Date, submit i) all the chemical and physical characteristics of the cement in compliance with the specifications and ii) a forecast on a monthly basis detailing his local cement requirements for the duration of the Contract in a form approved by the Engineer. Throughout the Contract period, the Contractor shall review this forecast at quarterly or more frequent intervals as may seem to him necessary or as may be required by the Engineer. Prior to commencing the Works, the Contractor shall establish a stockpile of cement based on his forecast of cement requirements and sufficient for maintaining his operations.

Throughout the Contract period, the Contractor shall so arrange further deliveries of cement to maintain his stockpile at three months' supply.

A.14. APPROVAL OF MATERIALS AND EQUIPMENT

A.14.1. General

A- All materials and equipment intended to be incorporated in the Works shall be subject to information given by the Contractor to the Engineer. For all the materials incorporated in the project, the Engineer shall give approvals, and the Contractor shall wait for this approval prior to order.

B- Unless otherwise authorized by the Engineer no material or equipment shall be shipped from its point of original manufacture or final shop assembly to the work site before it has been inspected in accordance with Clause 14.3.

A.14.2. Submission of Samples and Data

A- The Contractor shall submit for the approval of the Engineer samples, drawings, catalogues, cuts, diagrams and other descriptive data for all mechanical, electrical, architectural and such other materials and equipment as may be designated by the Engineer and which the Contractor proposed to incorporate in the Works. For certain materials and equipment data may be required to be submitted in accordance with a detail form furnished by the Engineer.

B- Items submitted shall be properly labelled to indicate the Project Contract number, Contractor, source of supply, manufacturer Contract Item number, and other data required by the Specifications.

C- All items shall be submitted in sufficient time, but not later than 90 calendar days prior to purchase, to permit proper consideration and action thereon without delaying the construction schedule.

D- Items sent for approval shall be shipped prepaid by the Contractor and the Contractor shall give the Engineer advance notice in writing of all items shipped.

E- The results of the tests shall generally indicate:

- Sample identification numbers.
- Sample origin.

- Part of the Works represented by the sample.
- Sampling date.
- Description of tests with reference to the relevant standards.
- Test results (with appropriate units when applicable).
- Date of tests.
- Reference of laboratory undertaking the tests.
- Conclusion (Satisfactory or Unsatisfactory).

A.14.3. Inspection at the Place of Manufacture

A- To allow possible inspection of materials and equipment in the course of or on completion of preparation or manufacture, the Contractor shall give the Engineer written notice of the workshops and places where the materials and equipment are manufactured or stored and advise him of the state of progress, so that the inspection may take place at appropriate times and without delaying the dispatch of materials and equipment to the Site. In particular, the Contractor will inform the Engineer of the date of final erection tests or inspection test prior shipping. Inspection and Testing Plan (ITP) must be submitted and approved prior to start of fabrication.

B- If the Employer and/or the Engineer decides to attend these tests (or any representatives duly nominated) abroad of Lebanon, the cost of the transport, flights tickets and accommodation shall be paid by the Contractor (for 3 persons for both sides, for 2 times).

C- The Engineer could make tests on concrete, concrete aggregates, embankment materials, filter materials and other materials as he may from time to time elect, and the Contractor shall provide such samples or assistance in sampling materials at the Site as the Engineer may reasonably require. Testing by the Engineer shall in no way relieve the Contractor of his responsibility to test materials to ensure that they meet all the specified requirements and to control their quality.

A.14.4. Manufacturer's Certificate of Compliance

In the case of standard labelled stock products of standard manufacture which have a record of satisfactory performance in similar work over a period of not less than 2 years, the Engineer may accept a statement from the Manufacturer attested by a notary public certifying that the product conforms to the applicable Specifications.

A.14.5. Mill Certificates

In the case of materials for which such practice is usual, the Engineer may accept the manufacturer's certified mill and laboratory certificate.

A.14.6. Certificate of Origin

The contractor must submit an original certificate of Origin for the material and equipment ordered specifically for the project. The COO shall be part of supporting documents of the Interim Payment Certificate.

A.14.7. Service Record

If a demonstrable satisfactory service record is available for a material, certain specified tests may be waived by the Engineer.

A.14.8. Testing Laboratory Certificates

The Engineer may accept at its own decision a certificate from an independent commercial testing laboratory, satisfactory to him, certifying that the product has been tested within a period acceptable to the Engineer and that it conforms to the requirements of the Specifications.

A.14.9. Acceptance of Materials

The approval by the Engineer of any material or equipment shall in no way relieve the Contractor of any of his responsibilities for meeting all of the requirements of the Specifications and shall not prevent subsequent rejection if such material or equipment is later found to be defective or not conforming to the Specifications.

A.15. ASSEMBLY MARKING

All parts, or units of shop assemblies, shall be marked, or tagged with piece marks. Marks shall be in accordance with approved erection drawings, shall be clearly legible and so placed as to be readily visible when the part is being erected in the field. Before dismantling for shipment, connecting parts assembled in the shop shall be matchmarked to facilitate erection in the field and marked so as to identify each part with the assembly to which it belongs. The location of the matchmarks shall be clearly indicated on erection drawings. All parts or assembly of parts shall also be so marked as to identify them with this Contract.

A.16. SHOP CLEANING AND PAINTING

After shop assembly and inspection all parts of the Plant and Erection Equipment shall be cleaned and painted in accordance with the Specifications.

A.17. NAMEPLATES

A- Each major and auxiliary items of equipment shall have a nameplate permanently affixed thereto, or as directed, showing in a legible and durable manner the serial number, name and address of the manufacturer, rating data, electrical and mechanical characteristics, and other significant information, as applicable. Nameplate of distributing agents only will not be acceptable.

B- Nameplates shall also be provided where required for panel-mounted devices. Dials, gauges, and nameplates shall be marked with the nomenclature and units of measure in the metric system, and a schedule of such makings shall be submitted for review and approval by the Engineer.

C- All nameplates shall be in the English language.

D- Nameplates for Plant Identification and record purposes shall be manufactured from stainless steel with satin finish and engraved with black lettering of a size which is legible from the working level.

E- Warning plate shall be manufactured from stainless steel with satin finish and engraved with red lettering and sited in a position affords maximum personnel safety.

A.18. TESTS CARRIED OUT BY THE CONTRACTOR

A.18.1. Contractor's Testing Laboratory

The Contractor's laboratory shall be equipped to perform the following main tests:

A- Soils

- Identification.

- Compaction tests.
- Relative density determination.
- Permeability (laboratory).
- Particle size determination.

B- Concrete

- Fresh concrete analysis.
- Concrete workability.
- Concrete strength (compression, tensile strength by Brazilian test).
- Ultrasonic pulse velocity.
- Permeability.
- Concrete and grout modulus determination
- Temperature

C- Rock and aggregate

- Dynamic crushing tests.
- Particle size determination.

D- Cement

- Setting time.
- Blaine fineness.
- Heat of hydration.
- Mechanical characteristics (Strength, Young Modulus, Poisson Ratio).

E- Grout for injections

- Design and control.

F- Bituminous materials

- Design and control.

G- Laboratory computer equipment

The Contractor's Laboratory shall be equipped with one PC Computer from a well-known manufacturer accompanied by printing facilities.

H- Laboratory Alternative

If the Contractor wishes to not install a laboratory on site, he could propose to the Engineer the use of some others laboratories; based on the technology and staff and references of these laboratories the Engineer is not committed to accept.

A.18.2. Record Books of Tests Results

A- The sheets recording test results shall be of a type approved by the Engineer. The Records Book of tests and results shall be kept by the Contractor.

B- A copy of the Records Book shall be supplied once a month to the Engineer's Representative.

A.18.3. Special Equipment

In addition, the Contractor shall provide other Laboratory equipment or/and field-testing equipment as specified in the different Sections for the purpose of controlling particular works or/and determining in-site parameters. This equipment shall be available as necessary during the execution of such activities and could be removed from the Site as and when approved by the Engineer.

A.18.4. Meteorological Equipment

The Contractor shall supply and install at site or where instructed by the Engineer the following supplementary meteorological equipment:

- 2 recorder thermometers;
- 1 pluviometer (rain gauge)
- 1 hygrometer;
- 1 anemometer;
- 1 Simplified Piche meteorological shelter

A.19. QUALITY ASSURANCE AND QUALITY CONTROL SYSTEM

Quality Assurance (QA) Quality Control (QC) System covering all aspects of the Contract and the Works must be implemented, documented and maintained by the Contractor during the period of the Contract. The system shall comply with a recognised international Quality Assurance Standard. The System shall as a minimum consist of the following items.

A- General

The Quality Assurance System for the Company shall show the overall QA Organisation and the lines of responsibility, monitoring and action. Furthermore, the overall principles and procedures for establishing Quality Assurance Plans, Control Plans, QA Organisation, etc. for specific projects and contracts, sub-contractors and suppliers shall be provided.

B- The Works included in this Contract

- Quality Assurance Plan (QAP),
- Control Plan (CP).

As a minimum the Contractor shall, submit the QA System for the Company, Quality Assurance Plan and initial Control Plans for the Works included in this Contract, providing all important and critical activities for controls, inspections and tests to fulfil the specifications.

It is a general requirement that works are only sub-contracted to companies with an effective QA System.

C- Quality Assurance Plan (QAP)

The QAP shall as a minimum cover the following issues:

- The Contractor's staff and management organization for the project, management plan, and the quality assurance organization.
- The person responsible for the Contractor's QAS shall be authorized and qualified to take decisions on quality assurance issues, and his reference and communication lines to the Company's overall quality assurance organization and its responsible management shall be clearly shown. Persons performing quality control and testing shall be independent of those executing or supervising the Works.
- Management of documents.
- Management of procurement.
- Management of sub-contractors and suppliers, and requirements of their QAS's.
- Control of materials and workmanship, defects and material reconciliation, procedures for corrective actions, etc.
- Handling of deviations, additions or variations to the Contract Documents.

- The Contractor's system of management of current documentation for the execution of the Works shall include his sub-contractors and suppliers. It shall show:
- how it is ensured that only valid and approved documents are used for the execution of the Works and
- the method of recording variations and amendments to the documentation.
- The Contractor's initial proposed Control Plans describing important and critical verification activities based on the Tender Documents and the Contractor's own considerations in respect of execution of the Works.

D- Control Plans (CP)

The Contractor shall present for the Engineer's approval his detailed CP for all quality assurance efforts or measures for the Works or sections thereof. Such CP shall be presented to the Engineer not later than one week before the commencement of the Works or an approved section of the Works.

The CP shall include controls as specified in the Contract as well as any other normal and special controls that the Contractor finds necessary in order to ensure the quality of his work.

The CP shall for each control activity describe type, method, criteria for approval and documentation and who is responsible for performing the activity.

If the Engineer does not approve the CP as submitted, then the CP shall be amended for further approval. Subsequent changes in terms of the quality assurance work will not cause changes in agreed deadlines or contract sums.

E- The Contractor's control and documentation

1) General

During the Contract period, the Contractor shall, to the satisfaction of the Engineer and State Quality Control body, document that the Works comply with the quality assurance requirements stipulated in the Contract or approved during the Contract period.
Consequently, based on the approved QAP and the CP's, the Contractor shall during the execution of the Works carry out and document the quality control and its compliance with the stipulated requirements.

The Contractor's quality control does not limit his responsibility for the Works according to the Contract.

If the Engineer, during the period of the Contract, can substantiate that the Contractor's control and/or documentation shall be extended, the Contractor shall follow the Engineer's written instructions to this effect at his own cost and within the agreed time for completion.

2) Method of documentation and filing during execution of the Works

All control activities specified in the Control Plan shall be documented.

The CP's and all other issues related to the QA System shall be kept and maintained by the Contractor in the QA filing system, which shall be kept at the project site throughout the period of the Project.

On the basis of the QAP and CP's the Contractor shall produce the necessary forms for registration, log books, and check lists, etc. before work is commenced.

All documentation shall be provided with identification, the date and signature of the person responsible for the documentation. The identification shall as a minimum comprise:

- name of project,

- activity number as defined in the CP,
- time and place of the control activity.

The Engineer shall have full access to the filing system and he may without notice commission a quality audit.

The Contractor shall keep and maintain at his own costs the "Construction Book" (Log Book) according to Cypriot regulations and submit it regularly for the approval of the Engineer.

3) Documents at delivery

At the time of delivery of materials and goods, the Contractor shall submit the following documentation to the Engineer in one original and two certified copies, all certificates, documentation of tests etc. of materials and goods to be used in the Works.
All documents verifying that inspection, control and tests performed are in accordance with the Specifications.

Identification lists with cross-references between documents and materials and goods.

F- Quality control plan

a) Within 28 calendar days after the Commencement Date, the Contractor shall submit for the Engineer's approval a detailed description of his Quality Control Plan.

The plan shall include the quality control of all aspects of on-site construction, laboratory tests and on-site tests. It will include a quality inspection plan which will cover all items intended for inspection at the Contractor, Sub-contractors and Supplier's works and premises.

The plan shall contain but will not be limited to the following items:

- Organization chart for quality control
- Curriculum vitae of his staff exclusively appointed for all aspects of quality control during the Contract period.
- List of the Contractor's staff engaged in quality control and material testing.
- Name and address of site materials testing laboratory.
- List of laboratory equipment and description of the laboratory testing capabilities.
- Arrangements for any tests to be performed beyond the capability of the Contractor's laboratory.
- Procedures for comprehensive records.

b) The Contractor shall be responsible for establishing and maintaining procedures for quality control which will ensure that all aspects of the Works comply with the requirements of the Contract.

c) The Contractor shall be responsible for routine inspection, sampling and testing of all materials, workmanship, plant and measuring devices.

d) The Contractor shall establish at Site an efficient, comprehensive records facility and library. Books, drawings, standards, publications and manuals shall be indexed and their distribution controlled.

A.20. SITE FACILITIES TO BE PROVIDED BY THE CONTRACTOR

A.20.1. Access to Working Areas

The Contractor shall construct, operate, maintain and remove, if required, access routes to construction site areas from existing permanent access and/or site roads, such alternative proposals

and additional proposals by the Contractor as may be approved from time to time by the Engineer. Such proposals shall allow all phases of Construction.

Any of these accesses will not be removed except when formally agreed by the Engineer. Removal of these accesses shall be indicated with full details in the General Programme of Works.

A.20.2. Haul and Access Roads

A- The Contractor shall maintain the existing roads to different site works, as are necessary for the conduct of the work under the contract.

B- These roads will also be used as access roads by the Employer; the Engineer and other contractors engaged on the construction and completion of the Works.

C- As indicated in paragraph 2.5 the Contractor shall establish reasonable traffic regulations governing traffic on the roads maintained by him, and shall provide signs, pavement markings, traffic signals or other control devices and flagmen as may be required to maintain a safe and unimpeded flow of traffic.

D- Construction and maintenance of such haul and access roads not explicitly paid under separate bills will not be measured for payment as a separate Contract Item.

A.20.3. Electricity and Power Supplies

A- The Contractor shall make his own arrangements for the supply of electricity for his Temporary Works and other site usage, including tests.

B- The Contractor shall install, operate, maintain and subsequently remove equipment to provide sufficient supplies of electricity for the heating lighting and air conditioning of all offices stores laboratories and other temporary buildings used by the Contractor and by the Engineer in addition to any supplies he may require in connection with the construction of the Works.

C- In addition to his main source of power supply the Contractor shall where necessary, provide and maintain standby power supplies adequate to ensure the safety of the Works in the event of failure of the main supply irrespective of the timing or duration of such failure.

D- All site electrical installations shall be carried out in accordance with the current Regulations for the Electrical Equipment of Buildings.

E- The Contractor shall also install on his own expenses all the equipment for the permanent power supply of the plant; it shall submit to the Engineer, prior to order the equipment, the connection's design and equipment's specifications' approval by Electricité du Liban (EDL).

A.20.4. Lighting

A- The Contractor shall provide sufficient lighting to ensure that, at all times:

- safe working conditions are provided for all personnel on the work sites;
- the Works can be constructed in complete compliance with the Contract;
- complete inspections of all work in progress can be made by the Engineer, and security of the Works area and public safety measures are adequate and effective.

B- Unless otherwise directed the minimum intensity of illumination on ground or working surface to be provided for the various operators or work areas shall be as tabulated below:

Illuminance Operation or Area	Design Value / (Lux)	Minimum Measured Value / (Lux)
Earthworks and excavation	50	20
Concrete placing	100	50
Maintenance shops and mechanical and electrical works	300	200

C- The Contractor shall supply a suitable instrument to the Engineer for measuring the intensity of illumination. The instrument shall comply with BS 667 or equivalent standard as approved by the Engineer.

D- All moving plant used during night operations shall be equipped with sufficient lights and reflectors and fluorescent markings to ensure safe working conditions.

E- The submission to or approval by the Engineer of the Contractor's proposals for lighting shall not relieve the Contractor of any of his liabilities or obligations under the Contract.

A.20.5. Housing Facilities for the Contractor and His Sub-Contractors

A- The Contractor shall supply:

- Sufficient and adequate Site offices for his staff.
- Site offices for each of his sub-contractors (one office of 20 m² for each sub-contractor).
- Stores, workshops, compounds.
- Temporary accommodations and living facilities.
- Parking areas.
- All necessary services in relation with these works including water supply, lighting, drainage, heating, air conditioning and refuse disposal.

B- The Contractor shall be responsible for the general cleaning and maintenance of the areas including sanitary installations.

C- Buildings shall be complete ready for use including furniture, household appliances (stove, fridge, fan, air-conditioner, heater, lighting tubes and bulbs). Buildings shall be of the same type as the ones provided for its own staff.

D- The Contractor shall provide medical facilities as required by the Medical Officer for Health.

E- Details and layout of site offices and appurtenant buildings and services shall be to the general approval of the Engineer. The Contractor shall obtain any necessary approval from any local authorities concerned.

A.20.6. Water Supply

A- The Contractor shall make all provisions for the supply of water required for the execution of the Works as well as adequate quantities of potable water for all personnel.

B- The Contractor shall supply water required for the execution and testing of the Works including any hydrostatic or flooding test for pipes, tanks, lagoons and any installation of the WWTP.

C- The Contractor shall arrange for the water supply for his staff residences, labour camps, site offices, Works, workshops in addition to the supply of the Operator's Camp. Construction of tubewells, storage tanks, overhead tank, distribution system, and their proper running and maintenance shall be his responsibility. Potable water should be supplied 24 hours a day.

D- Water samples shall be tested every 3 months and certificates submitted to the Engineer indicating that the water is fit for human consumption from an agency approved by the Engineer.

E- The Contractor shall supply water to sub-contractors or other contractors for all their requirements.

F- The construction and maintenance of water supply facilities and the supply of water not explicitly paid under separate bills will not be measured for payment as a separate contract item, and it is assumed that those items are included in the Price Schedules.

A.20.7. Storage Areas

The Contractor shall make his own arrangements for the installation, operation and removal of this temporary storage and works and during the Contract period. Location and layout of these storage and work yard shall be subject to the prior Engineer's approval.

A.21. SEWERAGE

The Contractor shall make all provisions, subject to the Engineer's approval to construct, operate and maintain throughout the Construction Period a sewerage system comprising collection, treatment and disposal for all the camps.

A.22. SOLID WASTES

The Contractor shall make all provisions, subject to the Engineer's approval, for collection and disposal of solid wastes from all camps and work places. Wastes shall be collected at least twice a week and disposed in an approved location.

A.23. STORAGE AND USE OF EXPLOSIVES

Except as may be specifically approved by the Engineer in writing, the Contractor will not use explosives.

A.24. MEETINGS

A- The Contractor or his nominated Representative shall participate in weekly and monthly progress meetings convened by the Engineer and the Employer. Such meetings will generally be held at regular intervals through prior notice, but may also be convened without prior notice, in the event of any unusual occurrence, at the discretion of the Engineer and the Employer.

The Contractor shall immediately notify the Engineer of any unusual occurrence which he considers would justify an exceptional meeting.

B- The agenda shall include approval of the minutes of the previous meetings, progress of the works with respect to the schedule and analysis of the difficulties encountered in the work.

C- The minutes of the meeting shall be prepared by the Engineer and shall be deemed, after approval by the other participants, to be written confirmation of the declarations, instructions and decisions taken during the meeting.

D- The Contractor or his nominated representative shall be able to take decision during the meeting; otherwise, he shall be considered that the Contractor didn't attend the meeting.

A.25. RECORDS

A.25.1. Progress Reports

A- By the last working day of each calendar month, the Contractor shall submit two copies of a draft monthly progress report which shall contain at least the following information:

- Percentage progress of the Works compared with the approved programme, together with a description and percentage estimate of the work programmed for the following month.
- List of Contractor's Equipment on Site together with its deployment during the month.
- List of all personnel employed on Site.
- Accident record, if any.

- Summary of all work carried out during the month in question together with a description of any difficulties or problems occurring therein.
- Description of the daily climatic conditions during the month.
- Situation with respect to payments, together with the dates on which the Payment Certificates were submitted by the Contractor.
- Description of any claim made by the Contractor during the month.
- Progress photographs, when available.
- State of progress of customs clearance and local transport operations.
- Inventory of materials stored on Site.
- Tests in progress or already carried out during the month and those planned for the next month.

B- Within two working days of receipt of the draft monthly reports the Engineer will return to the Contractor one copy marked for amendment together with any separate comments for correction or addition to the draft report.

C- Within two working days of receipt of the Engineer's comments the Contractor shall submit ten copies of the final monthly progress report which will include all of the corrections, additions and amendments requested by the Engineer.

D- Each monthly report shall be in a format approved by the Engineer.

A.25.2. Photographs

A- To record the general progress of the work as well as particular details and special phases of erection and commissioning the Contractor shall take photographs at regular intervals, not more than 2 months.

B- Photographs of a given part of the Works shall as far as possible be taken from the same location and at the same angle.

C- Digital photographs will be provided on a CD.

A.26. OPERATION AND MAINTENANCE MANUAL

The Contractor shall provide an O&M Manual

Refer to Section VII – D: Operation and Maintenance Requirements

A.27. PROTECTION OF FINISHES

The Contractor shall take every care to prevent damage to the works and shall ensure that adequate protection is given to all works from the activities of following trades and any third party. Vulnerable parts of the works particularly liable to damage shall be protected as may be reasonably required by the Engineer and shall be deemed to be insured against damage in accordance with the conditions of contract.

A.28. SPARE PARTS

A- Spare parts

The Contractor shall provide the spare parts required by the Specifications and as recommended by the suppliers.

B- Spare part book

The Contractor shall give a spare part book. This spare parts book shall contain an assembly drawing of the plant which shall show all parts of the plant separately marked, designated and referenced.

The book shall also contain sketches of each part with the part number and the designation of the part. The material of the part shall also be indicated. These sketches and lists of parts shall be cross-indexed with the assembly drawings.

The spare parts book shall present information in a simple manner so that non-technical personnel may be able to indent these spare parts. The lists of spare parts required shall be made with reference to the spare parts book.

C- Duplicate

All spare parts shall be duplicates of the original parts furnished and interchangeable therewith.

D- Packing and packing list

The spare parts shall be suitably identified, treated and packed for a long storage in containers plainly marked "SPARE PARTS ONLY". A packing list, indicating the contents of each such container, shall be securely fastened in a moisture-proof envelope to the outside of the container. The packing list shall also provide the following information:

- Contractor and Contract number
- Identification, including Contractor's drawing number, reference of each spare part in the container.

E- Storage room

All spare parts shall be stored in a safe place under the responsibility of the Contractor up to the Taking Over Certificate; at this date, he will transfer the Spare Parts in a place indicated by the Engineer.

A.29. KNOW HOW TRANSFER AND TRAINING OF EMPLOYER'S STAFF

The Contractor shall provide a Know How Transfer and Training to the Employer's staff

Refer to Section VII – D: Operation and Maintenance requirements.

A.30. DAYWORK

A.30.1. General

The Contractor shall complete the Daywork prices in the Part 1.

No increase or decrease in price will be made for labour and materials daywork charges.

The daywork prices are not subject to adjustment.

Dayworks shall be paid, if any, through the Provisional Sum amount.

A.30.2. Labour Charges

The labour categories qualifying as reimbursable to the Contractor when employed on daywork shall include the gangers and charge-hands working with their gangs but shall exclude supervision for foremen level and above.

The Contractor will be reimbursed for the actual gross remuneration at the current rate for each labourer, tradesman, artisan, etc., which shall be deemed to include the following, but not limited to:

- Basic wage
- Unemployment insurance
- Workmen's compensation
- Service bonus
- Foods and water
- Transportation if any

The rates provided by the Contractor shall cover all the following cost:

- Supervision
- Overheads
- Profit
- Time keeping
- Accommodation
- Insurances
- Holidays with pay
- Travelling
- Subsistence
- Other bonuses
- Allowance for paid sick leave
- Allowance for non-productive time
- Recruitment costs
- Pay packet costs
- Pension
- Allowance for paid public holidays
- Allowance for paid annual leave
- Any statutory charges due
- Any and all other relevant to the employment of such employees including all liabilities, obligations, risks and incidentals for all employees to execute work by dayworks.

In addition,

- Only gangers and charge-hand who are working with their gangs shall be paid for under dayworks. The composition of each working gang on dayworks shall be approved by the Engineer prior to the commencement of such daywork. Any ganger or charge-hand who does not work with the gang shall be deemed to be in a supervisory category.
- Site Agents, Quantity Surveyors, Engineers, Foremen and the like shall be deemed to be covered in the rates and prices in the Schedules of prices.
- Overtime hours on daywork operations will be worked when expressly required by an instruction in writing from the Engineer. Overtime when required will be paid in the same proportions as actually paid to the employees.
- The daywork hours that labour work will be calculated from the time of arrival of the labour at the site where the work is to be carried out to the time of departure from such site but excluding meal breaks and rest periods, etc., i.e. the net time expended for the work.

The combination of the gross remuneration of and the percentage allowance on labour for daywork will be deemed to constitute the full inclusive charge to the Employer for each respective labourer, artisan, etc. Such combination shall include for all items of equipment and consumable which are normal to the particular labourer, tradesman or artisan in question including portable power tools,

manual plant and tools, etc. which have not been listed in the Daywork Equipment Schedule. It shall also include the use of water, lighting, power, the ventilation and sewerage facilities, the use and maintenance of stagings, scaffolding, workshops, stores and the like.

A.30.3. Contractor's Equipment Charges

The Bidder shall complete the Daywork Equipment Schedule in the Schedules of prices in order to provide prices for all items of equipment to be provided on Site which may be required to execute work under daywork.

The schedule must indicate clearly the total hourly operating rate, such as at 28 days prior to the closing date of tender, for each item of equipment. Such rates shall constitute the net charge to the Employer for the equipment, in a state fit to perform its intended function, including operating labour required for the equipment.

The cost of operators shall be included under equipment charges.

Equipment rates for daywork shall take account of the following:

- Small tools are not to be listed separately and the use of such tools will be deemed to be covered in the percentage allowance tendered for daywork labour charges and shall not be the basis of claims for payment under daywork charges.
- No addition shall be allowed on the quoted rate for the transport of the said equipment to and from the areas of work if the equipment is already on Site. If, however, the equipment is brought onto Site especially for the extra work ordered, then the transport shall be charged extra at cost, unless such equipment continues in operation for work of a normal nature under the Contract.
- The operating rates to be quoted are to include for items such as fuel, oils, power, consumable, ground-engaging tools, maintenance, repairs, etc. and other incidentals.
- Full payment of the bid rate will not be made for items not capable of operating properly or unable to perform any of their intended functions.

The daywork operating for equipment will be calculated from the separate times of arrival of each item of equipment at the site where the work is to be carried out to each time of departure from such site but excluding meal breaks and rest periods, etc. as arranged by the Contractor for the respective equipment operators. The time for transport between Working Areas or from a Working Area to other Site areas as relevant will subject to prior agreement with the Engineer, be included for reimbursement at the applicable daywork rates.

The minimum time paid for each item of equipment commencing work on each daywork order will be one hour (operating or standby if applicable) and thereafter the times operating or on standby will be paid to the nearest 0.25 hour (15 minutes).

The combination of the net cost of and the percentage allowance on equipment for daywork will be deemed to constitute the full inclusive charge to the Employer in respect of the incorporation of such materials in the Works except as allowed for in the Daywork Labour and Equipment items in the Price Schedule.

A.31. SITE OFFICES FOR THE ENGINEER

The Contractor shall supply fully furnished and equipped site offices for the sole use of the Employer and Engineer as follows:

- 4 x 15 m² offices
- 2 x 20 m² offices
- 1 x meeting room for 20 persons (at least 30 m²)

The Contractor shall supply the offices for the Engineer's and Employer's use along with the required connections for electricity, phone and water. He shall be responsible for adequate regular maintenance and repairs of structures, furniture, equipment and appliances therein.

Each office shall be fitted with electric lighting and wall mounted socket outlets: water heater; hot plate; an air-conditioner; fan; one 0.8 m x 1.5 m table with drawers; one fixed 0.9 m x 1.8 m desk with shelves above to take fold drawings; one stool; four chairs; wash basin and stand; one cupboard fitted with shelves; hat and coat hooks; one bed 0.90 m x 2.00 m.

The offices compound shall be provided with simple toilet facilities, chemical type or similar, located in a covered and enclosed privy separated from the field office, provided with lock and key. The type of toilet facilities, method of waste disposal, location and type of construction therefore shall be submitted to the Engineer for approval.

These offices shall have to be supplied not more than 28 days after the Engineer's Notice to Commence the Works.

A.32. TESTS ON COMPLETION OF DESIGN-BUILD

Refer to Section VII – Employer’s Requirements.

A.33. COMMISSIONING

Refer to Section VII – B: Performances Specifications.

A.34. CONTRACTORS KEY PERSONNEL

A.34.1. General

The Contractor shall nominate key personnel for the following positions:

- Project Manager; to be in charge of the overall management of the project during its whole lifetime;
- Process Expert; to be in charge of the process design of the plant and to give advice during the commissioning and the operation and maintenance;

Construction Site Manager; to manage the construction activities;

- Operation and Maintenance Manager; to be responsible during the operation and maintenance period;
- Architect; to be in charge of the architectural and landscaping aspects of the project.

The Contractor shall propose CVs for the key personnel in his proposal.

A.34.2. Minimum Qualifications of Key Personnel

The key personnel shall meet the following minimum requirements:

Project Manager:

- At least 15 years’ experience in project management
- Experience as project manager from at least 3 WWTP construction projects with capacity > 10,000 m^3/d
- Be fluent in English language
- Hold University Civil Engineering Degree or similar

Process Expert:

- At least 15 years’ experience in WWTP process design

- Experience as process designer from at least 3 WWTP construction projects with capacity > 10,000 m3/d including nitrogen removal and tertiary treatment
- Hold University Civil Engineering Degree or similar

Senior ICA Engineer (Instrumentation, Control and Automation):

- At least 10 years' experience in WWTP process design
- Experience as process designer from at least 3 WWTP construction projects with capacity > 10,000 m^3/d including nitrogen removal and tertiary treatment
- Hold University Civil Engineering Degree or similar

Senior Mechanical Engineer:

- At least 10 years' experience in WWTP process design
- Experience as process designer from at least 3 WWTP construction projects with capacity > 10,000 m^3/d including nitrogen removal and tertiary treatment
- Hold University Civil Engineering Degree or similar

Construction Site Manager:

- At least 10 years' experience in construction site management
- Experience as construction site manager from at least 3 WWTP construction projects with capacity > 10,000 m^3/d
- Hold University Civil Engineering Degree or similar

Operation and Maintenance Manager:

- At least 10 years' experience in WWTP operation and management
- Experience as O&M manager from at least 2 sewage treatment plants with capacity > 10,000 m^3/d, duration of each assignment minimum 2 years.
- Hold University Civil Engineering Degree or similar

Architect:

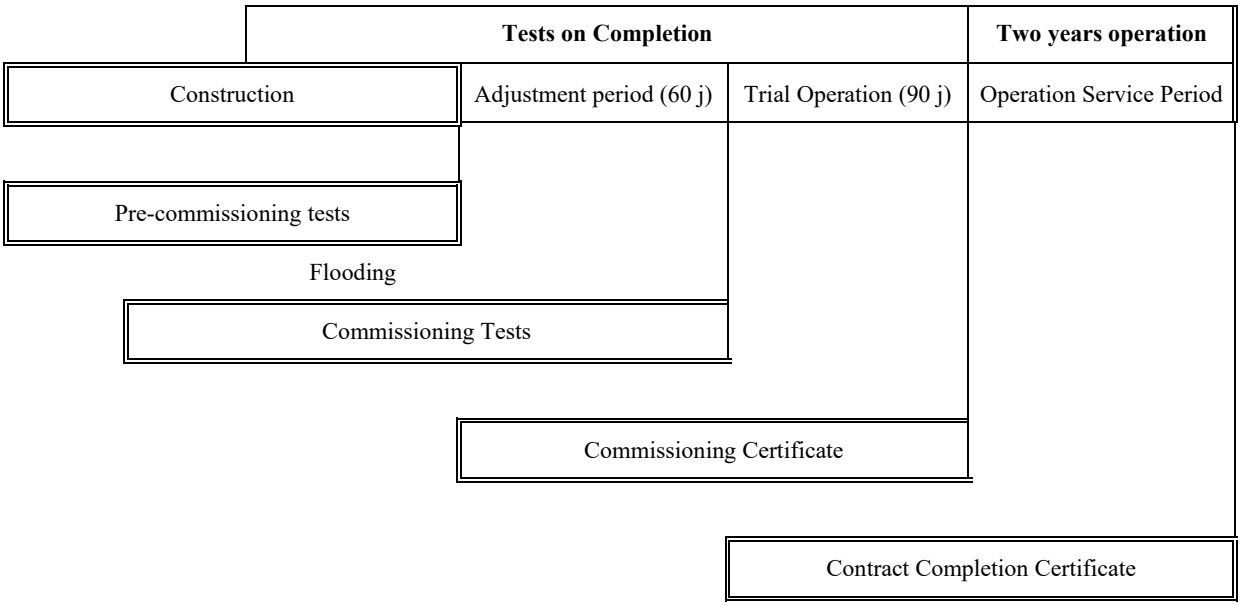
- At least 10 years' experience in industrial architectural design

A.34.3. REMOVAL AND/OR REPLACEMENT OF KEY PERSONNEL

Except as the Employer may otherwise agree, no changes shall be made in the key personnel. If for any reason beyond the reasonable control of the Contractor, it becomes necessary to replace any of the key personnel, the Contractor shall propose as a replacement a person of equivalent or better qualification.

APPENDIX

Test on Completion



SECTION VII – EMPLOYER'S REQUIREMENTS

PART B: PERFORMANCE SPECIFICATIONS FOR WWTP

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B.1 GENERAL PROVISIONS

B.1.1 Field of Application

The present Performance Specifications sets out the conditions of particular application for the design and works relating to the Contract for the implementation and operation for the "Expansion and Upgrade of Al-Ghadir Wastewater Treatment Plant Project – Phase I: Design, Build and Operate, Including Two New Sea Outfalls and Inspection & Assessment of Existing Sea Outfalls".

These design, works and services are to be carried out on behalf of the Council for Development and Reconstruction, acting as Employer for this project.

The project to be drawn up by the Contractor under the terms of the contract must be designed in such a way as to comply with the following, in order of priority:

- The Employer's Requirements, i.e. by order of priority the General Requirements, the Performance Specifications and the Technical Specifications.
- The terms of the "Contractor Proposal" of the successful contractor selected as a result of the competitive tendering procedure and appointed after finalization of the contract.

The contractor's project must be designed on the basis of the specifications given in this chapter. No waivers will be authorized.

In his design, the contractor alone is responsible for the dimensional design of the process structures, since he shall guarantee the performance of his installation.

The Design Report, prepared by Artelia/Dar Taleb, is provided for information only in Part 5.

B.1.2 General Rules for the Design

B.1.2.1 General Operation of the Plant

The treatment plant must operate normally throughout the year, in any weather conditions. During the execution of the works, the contractor must take extra precaution in order not stop or hinder the operation of the existing part of the plant.

B.1.2.2 Reliability of Operation

Purification efficiency must be as set forth in the rules of conformity detailed in chapter 2 of the present Performance Specifications. In addition to the appropriate sizing, break-downs and stoppages must be kept to a minimum, in particular by providing standby equipment that must be incorporated right from the design phase. The Tenderer shall in his proposal include an assessment of the reliability of the plant, including all measures taken to ensure the reliability.

The stand-by equipment required in chapter 3 is deemed to be the minimum stand-by equipment; the Contractor could propose extra stand-by equipment according to his design; such extra stand-by equipment shall be listed in the Contractor proposal.

B.1.2.3 Ease of Operation

The project must be designed in such a way as to ensure easy operation and guarantee maximum safety for personnel.

B.1.2.4 Environmental Constraints – Noise and Smells

Generally speaking, the installation must be designed with a view to keeping all nuisance for the vicinity to a minimum. As such, all treatment facilities shall be located in enclosed buildings.

B.1.2.4.1 Noise

The limitations and the treatment of noise are governed by a double objective:

- To limit the noise level for the operating staff of the plant. The plant is an industrial establishment and shall meet the current regulation concerning noise protection of workers.
- To limit the noise that could be anticipated to disturb the neighborhood.

The noise levels should meet the requirements of chapter 2.

B.1.2.4.2 Odors

The minimum odor levels defined in chapter 2 shall be respected. Buildings and facilities shall be enclosed and odor treated as required in chapter 3.

B.1.2.5 Architectural and Urban Planning Requirements

The Contractor shall acquaint himself with the regulations concerning the area, and take them into account in designing and carrying out the works, especially the Urban Planning Requirements and Beirut Airport regulations. To be noted as an example that the height of buildings shall not reach the flyovers levels limits of Aircraft mannering defined by the Lebanese Civil Aviation Authority.

In fact, the flyover envelope limits the current project buildings height below a range of 16m - 25m depending on the construction distances form the Aircraft runway centerline as shown in the drawings.

Buildings and structures must be in harmony with local architecture and be duly landscaped.

The architect's fees are included in the contract amount.

The successful Contractor shall also accept, if necessary, any modifications required by the authorities responsible for delivering the building permit, and shall not be entitled to claim any revision of the amount of the initial proposal.

B.1.3 Origin and Quality of Raw Water

B.1.3.1 Design Flows

The flow to the Expansion and Upgrade of Al-Ghadir WWTP Project is coming from a catchment area (Figure 1-1) which includes parts of Beirut (Southern) and the Cazas (i.e. Districts) of Baabda, Aley and Chouf. There are 47 Municipalities within the drainage area.

The total surface area is approximately 175 km^2 (17,500 ha). The coastline of the drainage area is approximately 24 km long, and extends a maximum distance of approximately 12 km to the east.

The Al-Ghadir Drainage area is subdivided into different zones from north to south according to the administration limits of each Municipality.

The 44 Municipalities (Zone I to Zone 44) all fall within the Al-Ghadir WWTP drainage basin. However, those that are situated along the eastern border of the basin have part of their wastewater flowing towards the Al-Ghadir WWTP and the remaining part flowing eastward towards existing water bodies.

The exception is Baabda settlement, which has the remaining part of its wastewater flowing northward towards the Borj Hammoud WWTP. The northern zone (Zone I) that belongs to Beirut Municipality (Beirut Area), has its wastewater flowing towards the Al-Ghadir WWTP while the wastewater of the remaining part of Beirut (eastern side of Beirut and Metropolitan area) flow towards the Borj Hammoud WWTP

The design population equivalent (PE) that shall be served by the plant at the date of 2050 (design year) is assumed to be 1,722,312 PE. The population equivalent is the equivalent connected to the network and resulting from the infiltration.

Flows have been defined for the horizon year 2050. The design flows are shown in Table 1-1.

Table 1-1 Design flows to Expansion and Upgrade of Al-Ghadir WWTP Project

Parameters	Dry season	Wet season
Daily flow, m^3/d	282,459	334,129
Average hourly flow, m^3/h	11,769.13	13,922.04
Average flow, m^3/s	3.27	3.87
Peak hourly flow, $m^{3/}/h$	16,316.04	18,468.92
Peak flow, m^3/s	4.53	5.13
Peak Factor	1.385	1.33
Duration, d/year	300	65

The population is considered the same in both dry and wet seasons. The population equivalent is different between both seasons due to infiltration. The plant process shall be designed based on the dry season flows. The plant hydraulics shall be able to accommodate the peak wet weather flow.

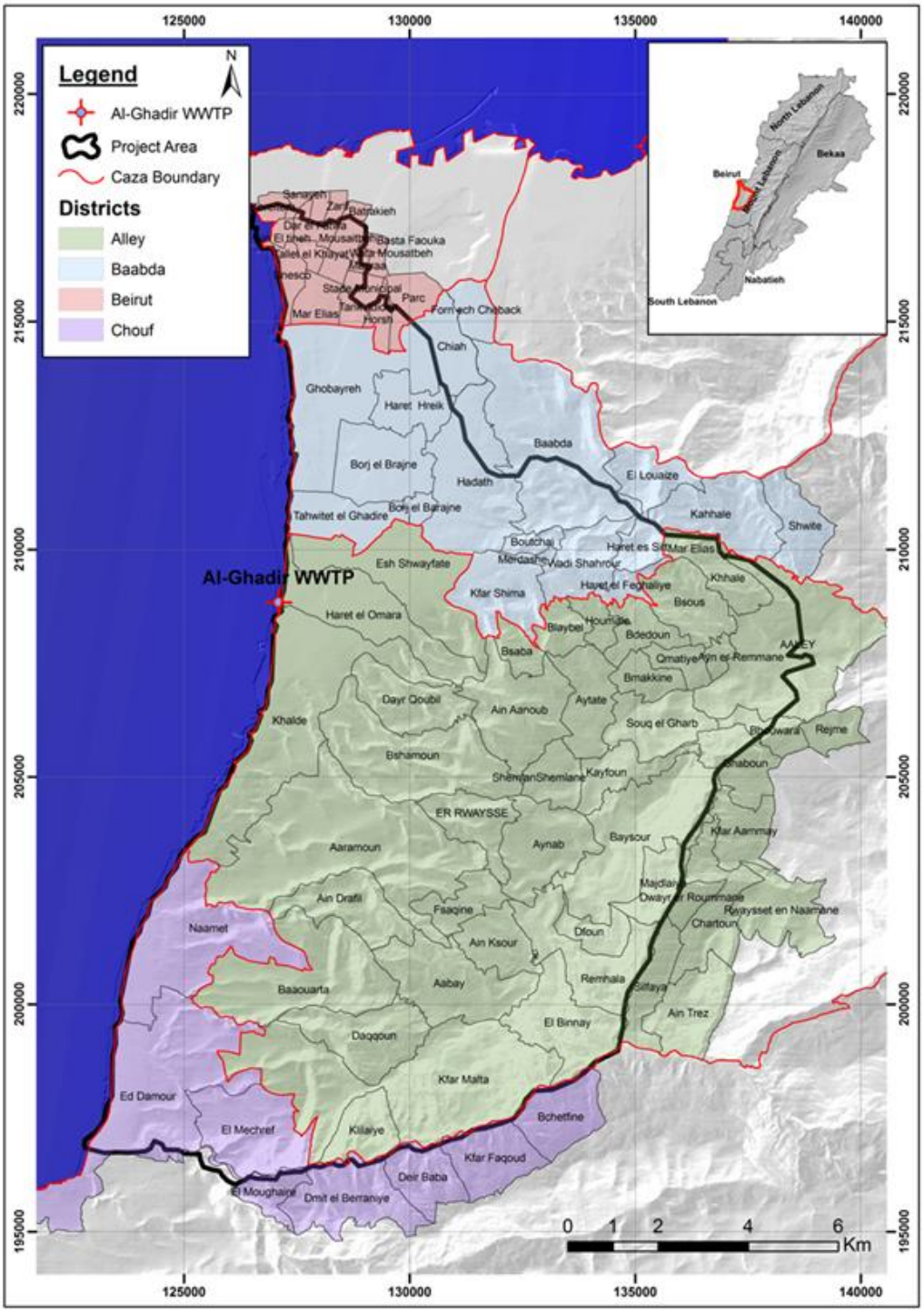


Figure 1-1 Al-Ghadir WWTP Drainage Area

B.1.3.2 Wastewater Loadings

For the main parameters used for the design of the plant (BOD_5, COD, TSS) there is no major contradiction between the observed concentrations and the calculated concentrations. Therefore, the Population Equivalent ratios can be used for the definition of the reference loads.

The table hereafter presents the design loads defined on the basis of the given Population Equivalent (PE) rates.

Table 1-2 Design Loads to Expansion and Upgrade of Al-Ghadir WWTP Project

Parameters	Concentration, mg/l	Dry weather, kg/d	Wet weather, kg/d
BOD_5	360	101,685	106,852
COD	700	197,721	210,122
TSS	450	127,107	135,890
TKN	72	20,337	21,887

B.1.4 Receiving Body – Wastewater Discharge

Treated wastewater will be discharged to the sea.

B.1.5 Destination of By-Products

The waste derived from the treatment is to be disposed of as follows:

- Screenings: evacuation to landfill within 100 km (distance to be confirmed),
- Grit: recycling as backfill material after high level treatment (included in this contract),
- Fat, oil and grease: the grease treated at the WWTP shall be biologically treated on site,
- Sludge: evacuation after treatment to landfill within 100 km (distance to be confirmed)

B.2 REQUIRED PERFORMANCE LEVELS

B.2.1 Treatment Quality

B.2.1.1 Treated Wastewater

The wastewater plant shall be designed and sized in accordance with the capacities defined in section 2.2 and the discharge standards specified in below Table 2-1.

Table 2-1 Treatment Requirements for Primary Treatment

Parameter	Maximum concentration	Minimum Performance
BOD_5	234 mg/l	35%
COD	490 mg/l	30%
TSS	180 mg/l	60%

Note: More tolerance will be provided for Phase II.

Table 2-2 Treatment Requirements for Secondary Treatment (Phase II)

Parameter	Maximum concentration	Minimum Performance
BOD_5	25 mg/l	80%
COD	125 mg/l	75%
TSS	30 mg/l	90%

B.2.1.2 Sludge Treatment

The treatment process must produce sludge with characteristics meeting the following targets:

- Sludge shall be mechanically dewatered and stabilized with addition of hydrated lime.
- Sludge with a dryness objective of 25±2 % dry solids (DS) prior to lime stabilization.

B.2.1.3 Waste Treatment

The following performance values are required:

- Screening waste after compacting: dry matter content greater than or equal to 35%.
- Washed grit:
  - Organic matter content less than or equal to 5%,
  - Dryness greater than or equal to 80%.
- Grease treatment: minimum efficiency of biological grease treatment
  - 80% expressed as HEM
  - 60% on total COD

B.2.1.4 Odor Treatment

a) Work areas

In the equipment rooms, the ventilation system must be designed to comply with the following minimum requirements:

- H_2S ..... < 7 mg/Nm³
- RSH ..... < 1 mg/Nm³
- NH_3 ..... < 15 mg/Nm³
- RNH ..... < 2 mg/Nm³
- Aldehyd and Ceton ..... < 0.5 mg/Nm³

In the staff rooms (offices, laboratory, etc.), the following Threshold Limit Values must be respected:

- H_2S ..... < 1.4 mg/Nm³
- NH_3 ..... < 3.6 mg/Nm³
- RNH ..... < 0.1 mg/Nm³
- Aldehyd and Ceton ..... < 0.3 mg/Nm³

b) On leaving the odor treatment unit

The structures which must be enclosed and deodorized as a minimum are specified in chapter 3 of these Performance Specifications. On leaving the odor treatment unit, the treated air concentrations must not exceed the following values, which correspond to the human perception threshold:

- H_2S (hydrogen sulphide) ..... < 0.1 mg/Nm³
- RSH (mercaptans) ..... < 0.1 mg/Nm³ (expressed as methyl sulphide)
- NH_3 (ammonia) ..... < 1 mg/Nm³
- RNH (amines) ..... < 0.1 mg/Nm³
- Aldehyd and Ceton ..... < 0.3 mg/Nm³

These values shall also have to be respected 98% of the time at all points of the property boundary for the site.

B.2.1.5 Noise

At all points bounding the treatment plant site, noise levels must comply with the following specifications:

- maximum levels:
  - 65 dB(A) by day (7 a.m. to 8 p.m.),
  - 60 dB(A) during intermediate periods:
    - ~ Working days: 6 a.m. to 7 p.m. and 8 p.m. to 10 p.m.
    - ~ Sundays and public holidays: 6 a.m. to 10 p.m.
- 55 dB(A) by night (10 p.m. to 6 a.m.).
- Maximum emergence conditions:
  - By day (7 a.m. to 8 p.m.) and during intermediate periods: 5 dBA,
  - By night (8 p.m. to 8 a.m.): 3 dBA.

In the equipment rooms, the sound power emitted by all of the equipment in normal operating conditions must not exceed the following values:

- Total value: 80 dBA

In the administrative/office building, noise levels must be below the following values:

- Total value 45 dBA.

B.2.2 Treatment Capacity

B.2.2.1 Wastewater Treatment

a) Design loads

The reference loads are the maximum permissible loads on the entire wastewater treatment line and for which the treatment level defined in paragraph 2.1.1 must be guaranteed.

The reference loads correspond to the peak dry-weather loads at year 2050 horizon

Table 2-2 Design Loads for The Wastewater Treatment

Parameter	Reference loads (Dry weather) (year 2050)	Reference loads (wet weather) (year 2050)
BOD (kg/d)	101,685	106,852
COD (kg/d)	197,721	210,122
SS (kg/d)	127,106	135,890
TKN (kg/d)	20,337	21,887
Daily flow (m^3/d)	282,459	334,129
Hourly peak flow (l/s)	4.53	5.13
Duration of the period (days/year)	300	65

B.2.2.2 Sludge and Waste Treatment

The sludge and waste treatment equipment (as well as the buffer stores) shall be sized so as to enable the shop to operate 7 days per week, with operators present for a maximum of 10 hours per day.

B.2.3 Guaranteed Performance Range

The required performance levels (whenever applicable i.e. Phase I and/or Phase II) should be met when the following conditions are simultaneously met:

For each set of design loads and corresponding treatment targets:

- The daily loads of BOD_5, COD and SS received are between 33 and 100% of respective design loads;
- The daily loads of Kjeldahl nitrogen (TKN) is between 33 and 100% of the design nitrogen and phosphorus loads;
- The hourly peak flow rate is less than or equal to the design hourly flow rate;
- The daily flow rate is between 33% and 100% of the design daily flow rate.

The increase in daily pollution loads of BOD_5, COD, SS received by the installation on a particular day, with respect to the average load over the previous 5 days, is not greater than 100%.

B.3 PROJECT DESIGN

B.3.1 General

B.3.1.1 Limits of Services

The limits of the works covered by this contract are as follows and as shown in the Tender Drawings (Part 4):

- Upstream limit for wastewater:
  - connection to the existing DN1500 AC pipe coming to the inlet lifting station (Archimedean screw pumping station) and existing DN1200 overflow/bypass
- Downstream limit for wastewater: connection to the existing sea outfalls (emergency gravity sea outfall and pumping station)
- All works for the wastewater treatment plant and for the conversion and landscaping of the site within the site fencing (existing plant and new site) and the access road between the 2 sites, as shown on Tender drawings.
- The access road from the limit as shown on Tender drawings.

The expansion and upgrade of Al Ghadir WWTP shall consist in 2 phases as described in clause 3.1.3 (Description of the plant). The current construction contract consists of Phase I only; however, the contractor shall accomplish in this contract the detailed design for the complete plant i.e. phase I and phase II.

B.3.1.2 Admissible Process

The plant shall necessarily include the rehabilitation and the upgrade of the existing units and addition (for phase 1) of primary treatment, sludge treatment, odor treatment, power generation, SCADA and related ancillaries. For phase 2, the addition of secondary treatment units, related sludge treatment, odor treatment, power generator and SCADA shall be considered. The plant process shall be CAS (Conventional Activated Sludge).

With reference to the following process, The Contractor shall select and justify in the Contractor proposal the structures and equipment to implement in order to satisfy the requirements.

In addition, the existing plant constructions shall be rehabilitated and upgraded in order to satisfy the project design requirements.

The existing wastewater treatment plant comprises the following constructions:

Screw pumps lifting station refurbishment and expansion, screw pumps motors and MCC building refurbishment and expansion, Bar screens refurbishment and upgrade to fine screenings, screenings conveying and compaction, grit classifiers, aeration degritting tanks refurbishment and expansion, main pumping station refurbishment (Which includes operator room and laboratory), transformers and generators building refurbishment and expansion, guard house refurbishment, primary sedimentation tanks, Interim Pumping Station (without equipment), Flowmeter chamber and valve chamber (without equipment), Transformers Substation, Administration building, Workshop and Store, Fuel Tank, Degritter Blowers Room, Odor control system, external structures, works and landscaping

Alternative Tenders are allowed. Only the alternative of the lowest evaluated Tenderer will be opened and analyzed.

B.3.1.2.1 Secondary Treatment

The only admissible process for the secondary waste water treatment shall be the following:

- CAS (Conventional Activated Sludge)

B.3.1.2.2 Sludge Process

The only admissible process for the sludge treatment shall consist of thickening, anaerobic digestion, dewatering, lime treatment.

B.3.1.2.3 Odor Treatment

The only admissible process for the odor treatment shall consist of bio-trickling filter.

B.3.1.3 Description of the Plant

The Project includes expanding the capacity of the existing preliminary WWTP from 140,000 m^3/day to approximately 282,459 m^3/day, and upgrading the treatment process from preliminary to primary level in phase I and to secondary level in phase II of the project. Additionally, the project will incorporate sludge treatment, power generation, odor control measures and SCADA.

The existing Al-Ghadir plant consists of preliminary treatment works which include the following units:

- Inlet works of the incoming wastewater from the sewage networks and the tanker trucks
- Lifting station (Archimedean Screw Pumps)
- Automatic Coarse Screens with screenings compactor
- Grit and scum removal with grit classifiers
- Pumping station for the sea outfall equipped with three pumps: one in operation and two on standby to accommodate low flow conditions. It also includes space for a fourth pump to be added in the future to handle increased flow.
- Main sea outfall for discharging preliminarily treated wastewater into the sea, (DN 1200mm extending 2,500 meters into the sea).
- Emergency sea outfall, for the discharge of untreated wastewater (DN 1500mm extending 500 m into the sea); and Bypass/Overflow Facilities.
- Transformers/Generators

In order to comply with the future flows and discharge requirements, set by Lebanese legislation and EU standards, the treatment scheme of this project will include the following components:

- Phase 1
  - Preliminary Treatment Unit, to include:
    - ~ Refurbishment, capacity extension and upgrade of Initial Lifting Station;
    - ~ Refurbishment, capacity extension and upgrade of Screening system to include additional fine screens and their ancillaries
    - ~ Refurbishment, capacity extension and upgrade of Aerated De-gritting Chambers and their ancillaries
    - ~ New Primary Treatment Unit (lamella settling tanks);
    - ~ Primary Sludge Treatment Facilities, including:
      - ❖ Gravity Thickeners, for primary sludge (PS);
      - ❖ Sludge Screening, for primary sludge;
    - ~ Buffering-Mixing tanks, for PS and SAS;
    - ~ Anaerobic Digestion Treatment, for mixed sludge;
    - ~ Mechanical Dewatering of digested sludge;

- ~ Storage of dewatered sludge.
- ~ Biogas Utilization Unit, including:
  - ❖ Biogas Collection and Storage;
  - ❖ Combined Heat - Power (CHP) Engines, for power production;
  - ❖ Emergency Flaring Station.
- ~ Odor control
- ~ SCADA
- ~ Electrical System

- Phase 2
  - Secondary Treatment Unit, including:
    - ~ Anoxic tanks and their ancillaries;
    - ~ Aeration tanks and their ancillaries;
    - ~ Secondary Settling Tanks and their ancillaries;
    - ~ Chlorination/de-chlorination tanks and their ancillaries.
  - Secondary Sludge Treatment consisting of:
    - ~ Mechanical Thickening, for surplus activated sludge (SAS);
    - ~ Buffering-Mixing tanks, for PS and SAS (Extension of Phase 1);
    - ~ Anaerobic Digestion Treatment, for mixed sludge (Extension of Phase 1);
    - ~ Mechanical Dewatering of digested sludge (Extension of Phase 1);
    - ~ Storage of dewatered sludge (Extension of Phase 1)
    - ~ Upgrade of Biogas Utilization Unit, including:
      - ❖ Biogas Collection and Storage (Extension of Phase 1);
      - ❖ Combined Heat - Power (CHP) Engines, for power production (Extension of Phase 1);
      - ❖ Emergency Flaring Station (Extension of Phase 1).
    - ~ Odor control (Extension of Phase 1)
    - ~ SCADA (Extension of Phase 1)
    - ~ Electrical system (Extension of Phase 1)

The WWTP will use the Conventional Activated Sludge Process with sludge treatment and anaerobic digestion and power generation. In addition to the process equipment mentioned earlier, the following service buildings shall be included as a minimum:

- Influent lifting station building extension
- Treated Sewage Effluent pumping building refurbishment
- Intermediate pumping station (The transfer of the primary effluent to the biological treatment)
- RAS/SAS pumping stations
- Air blowers building

- Influent/effluent distribution chambers, Flow Measurement systems
- Sludge Dewatering building
- Sludge Stocking silos
- Services Building: administration, workshop, guardhouse, accommodation, chlorination, etc.
- Standby Power Generation Facilities, Transformer Room (medium/low voltage), connection to the Public Power Grid
- Supervisory Control and Data Acquisition (SCADA) system
- Landscaping, access roads inside and outside the site, mainly access road between the existing plant location and secondary treatment site.
- Works return pumping station

B.3.1.4 Use of Available Area

The work area included in the scope of work of the Contractor as limited by the boundary fence.

- The area available for the construction of the new wastewater treatment plant consists of 2 areas;
  - Existing plant area of 31,300 m²
  - New reclaimed area of approximately 131,850 m^2. Considering the setback from airport runway and from archaeological ancient wall, the remaining available for construction is 112,255 m^2.
  - The new adopted reclaimed area to be fenced, including non-constructed area/access road part inside the set back from the airport runway, is approximately 119,318 m^2
- Additional temporary working areas for the Contractor's use during the construction period can be installed on the site after approval of the Engineer.

B.3.1.5 Reliability of the Installation

The reliability of the installations, as well as their performance, are major requirements that must be met by the Contractor.

The installation shall, as a minimum, consist of multiple parallel treatment lines in order to simplify maintenance operations. Provision shall be made for cross-connection of the lines between all facilities.

The installation design must take account of this requirement (reliability analysis, failure risk analysis, etc.), which is more particularly associated with meeting the following reliability targets (non-exhaustive list):

- Installation design must guarantee personal safety,
- Installation design must prevent any risk of flooding or equipment damage,
- Minimized risk of failure leading to damage to the installations treating sludge or other by-products or making it impossible to accept external inflows,
- Minimized risk of failure leading to damage to ventilation and odor treatment unit operation.

It must be made clear that the reliability targets must include the down times linked to equipment maintenance and servicing.

The project presented by the successful contractor must include all installations required for the plant to operate perfectly.

All necessary provisions must be made to ensure that the design of the installation (Phase I + Phase II) shall be reliable and to minimize shutdown and breakdown times. The main pieces of equipment must be fitted on the spot with a backup system or must be available in the storage place:

- Lifting (wastewater, sludge and mixed liquor recirculation, sludge extraction), only on the spot backup equipment is allowed;
- Pre-treatment;
- Primary treatment;
- Aeration;
- Sludge treatment and biogas utilization
- Reagent injection (including lime)
- Air extraction and odor treatment
- Outlet pumping station (sea outfall);
- Electrical Panels
- PLC
- SCADA.
- Power generation
- Access road

The successful contractor must provide for electrical installations ensuring a looped power supply.

In the event of a power failure, the installation must be capable of backing up all data and restarting automatically without incurring damage when the power supply is restored.

If necessary, the contractual memorandum on reliability, describing the arrangements made, shall be supplemented during the design and implementation phases.

B.3.1.6 Maintenance

B.3.1.6.1 Preventive Maintenance

The installation is designed to meet the required performance levels in all situations, even during maintenance operations. The numbers of treatment lines, machines and their capacity, and standby equipment are defined with this in view.

3*.1.6.2. Corrective Maintenance*

The installation is designed to minimize the time required for corrective maintenance. With this in view, it must have the following characteristics:

- easy monitoring and detection of break-downs and abnormal operation,
- accessibility and ease of dismantling/re-assembly (e.g. sufficient space provided for easy operation and maintenance activities),
- easy lifting and handling of the largest items of equipment,
- areas provided for access by maintenance staff.

B.3.1.7 Hydraulic Operation

B.3.1.7.1 General Provision

The design shall be carried out for minimizing the lifting operations; as a general rule, the water shall be lifted at the entrance of the station if necessary, and except particular process under pressure,

including sludge recirculation and sludge extraction, it is assumed that no more water lifting shall be necessary.

B.3.1.7.2 Hydraulic Grade Line

The hydraulic grade lines shall be calculated from the reception chamber to the discharge of the treated effluent under the following conditions:

- Normal level: i.e. level corresponding to the reference daily flow (dry weather peak flow) under normal operation.
- Extreme level: i.e. level corresponding to the reference hourly peak flow under exceptional operation, as described hereafter.

These levels shall be written on the hydraulic profile and on the civil guide drawings.

The internal lifting stations, the location of facilities and the head losses in pipes should be designed such that all overflow weirs operate unflooded, with a minimum distance of 5 cm from the top of the sill to the downstream water level and a maximum distance of 15 cm.

A minimum freeboard of 15 cm is designed for all the structures above the extreme hydraulic level.

B.3.1.7.3 Emptying of Structures – Low Point Release Devices

All structures containing liquid (water, sludge, reagents, etc.) must be designed so that they can be emptied by gravity flow. In exceptional cases, pump units provided for in the contract may be used.

All low points of the installation (miscellaneous structures, technical equipment rooms, roads, etc.) must be provided with sumps for removal of liquid by gravity flow or pumping (pump included in the contract).

B.3.1.7.4 By-Passes

Structures corresponding to the various stages of wastewater treatment must be fitted with by-passes so that they can be isolated in the event of an incident, temporarily preventing their normal operation.

B.3.1.7.5 Distribution

Equal distribution between various treatment lines or structures must be as strict as possible. This is checked downstream on each of the lines or structures.

The distribution structure should preferably be of the overspill type. This must be adjustable and easily accessible.

B.3.1.8 Equipment

B.3.1.8.1 Service Life

The service life classes and corresponding service life hours for equipment shall meet the minimum requirements as shown hereafter in Table 3-1, in accordance with BS EN 12255-1.

Table 3-1 Service Life

Equipment type	Service life class	Service life	Standard reference
PRELIMINARY TREATMENT			
- Mechanical equipment for screening, grit and grease removal	3	20 000 h	BS EN 12255-3
- Air supplying systems of air lift.	2	10 000 h	BS EN 12255-3
DECANTATION AND CLARIFICATION:	4	50 000 h	BS EN 12255-4
		20 000 h	BS EN 12255-4

Equipment type	Service life class	Service life	Standard reference
- Rotating axis mounted on ball bearings, intermediate bearings and gears - Wheel drives, electrical motors - Lifting equipment	3 2	10 000 h	BS EN 12255-4
TANKS AERATION AND AGITATION: - Gears and bearings of surface aerators - Electrical motors - Mixers	 5 3 4	 80 000 h 20 000 h 50 000 h	 BS EN 12255-6 BS EN 12255-6 BS EN 12255-6
SLUDGE TREATMENT: - Motors - Gears and bearings of pumps, compressors, scrappers, mixers, dewatering equipment or similar	 3 4	 20 000 h 50 000 h	 BS EN 12255-8 BS EN 12255-8

B.3.1.8.2 Corrosion Protection

The Contractor's attention is drawn to the corrosive character of the atmosphere in the treatment plant.

All equipment must therefore be made of corrosion-proof material. Galvanized steel is prohibited.

Unless otherwise specified, the following rules shall apply:

- Mechanical equipment in contact with waste water: Stainless steel 316L
- Mechanical equipment in contact with clarified water: Stainless steel 316L
- Materials for steel structure in treatment places: Stainless steel 316L
- Materials for hand railing and steel works: aluminum or inert materials
- Cable supports: aluminum, inert materials or stainless steel 316L
- Materials for handling equipment: steel with epoxy cover painting
- Materials for ventilation and exhaust ducts, reagents pipe: PVC, HDPE

The defects liability period for the equipment is set out in the Conditions of Contract.

B.3.1.8.3 Standardization of Equipment

As far as possible, the Contractor shall endeavor to ensure that equipment used in the plant is of the same brand and keep the sizes of mechanical and electrical equipment to a minimum in order to limit the number of spare parts required.

B.3.1.8.4 Lifting and Handling Equipment

Equipment shall be provided for lifting, transporting and removing outside the buildings all equipment requiring regular maintenance, notably pumps, motors, fans, etc.

Outside access must be provided for trucks to pick up the equipment.

Lifting equipment (movable if necessary) must be provided for handling stoplogs, trapdoors, inspection hole covers and any items exceeding 15 kg in weight.

Lifting equipment must be provided for loading large items weighing more than 1000 kg on to trucks, in a single operation.

The capacity and type of such equipment shall be adapted to the items to be lifted and to the frequency of use (bracket crane, gantry, bridge crane, monorail, etc.).

Manual controls must not require a force of more than 20 daN for lifting and pulling, and more than 10 daN for operating cranks or drive wheels.

Controls requiring greater forces than these shall be electrically operated from the ground.

B.3.1.8.5 Submerged Equipment

It must be possible to lift all submerged equipment (pumps, mixers, aerators, diffusers, etc.) from the surface in the above conditions so that they can be maintained without emptying the structures.

B.3.1.9 Limitation of Disturbances

B.3.1.9.1 Odors

The different areas where odor generation can be expected should be located indoors, according to the prescriptions further on in this chapter. These different areas should be ventilated and the malodorous air shall be treated before discharge to the atmosphere.

B.3.1.9.2 Noise

The installations shall be designed at the outset firstly to comply with chapter 2 and secondly to reduce noise disturbance as far as possible.

Special arrangements must be made to prevent the propagation of noise. Noisy machines must be housed in suitably insulated and ventilated rooms.

Special attention must be paid to the handling of doors and windows and the air intakes and outlets (sound traps).

These arrangements are described in detail and accompanied by a calculation note during the working design phase.

B.3.1.10 Protection and Safety of Operating Staff

It is stipulated that the conditions in which operating staff work to operate the installations built by the Contractor must comply in all respects with the labor legislation in force on the date on which the contract is signed.

The installation is fitted with the necessary monitoring and safety systems for preventing any disorderly operation of the equipment that may present a danger to staff, equipment or the environment.

A push-button type emergency circuit-breaker must be installed near each rotating machine. If a machine is stopped with this device, it cannot be restarted automatically or manually from the central cabinet.

All rooms shall be provided with emergency exits complying with the regulations in force.

All permanent means of access to machinery (ladders, platforms, stairways, etc.) shall be in accordance with EN ISO 14122.

In addition to the special contract conditions concerning safety, the Contractor shall provide and install the following equipment:

- Lifeline with harnesses for exceptional operations.
- Minimum width of passageways: 1 m except in exceptional circumstances.
- Ladder with safety cage for any height above 2.5 m.
- Removable safety grid for all ground-level manholes on basins or structures over 2.5 m high.
- Assisted handling for all loads over 50 kg.
- Safety lighting in all premises.
- Circuit-breakers and mushroom-head off buttons for all electrical equipment.

The specific safety equipment for the treatment processes is as follows:

- H_2S and CH_4 detectors at the general effluent inflow, in each pit and in the fan plenum chambers + explosiveness and O_2 in the general distributor.
- Buoy with mooring ropes and pole at each end of the tank building.
- Descending safety ladder on mobile catwalks.
- Safety eye baths at each reagent unloading cabinet and each location where reagents are used.
- Splash confinement (Plexiglas box) around equipment (pumps, flowmeters, etc.) on reagent networks.
- Maximum confinement of gaseous atmospheres above effluent.
- Ventilation of all process rooms.
- Specific atmosphere treatment by means of odor treatment and air circulation.
- Monorail and lifting tackle cut-offs triggered by blockage detection system.
- Confinement cases for all reagent tanks.
- Frontal and circular scraper bridge cut-offs triggered by blockage detection system, with object removal blade.

B.3.1.11 Pumping Stations

A «pumping station» is defined as a place fitted with more than 1 pump for lifting water, sludge, grit grease, etc. from one structure or equipment (pits, sumps, channels) toward other equipment or structures.

The dimension of the upstream structures shall be designed in order to not overpass 6 starting within one hour for water and sludge and the starting' number specified by the supplier for the others.

Unless otherwise specified and whatever the number of pumps, 1 stand-by pump shall be enable on the spot and shall start up automatically of another pump breaks down; this pump shall have the same characteristics than the other ones; a circular working could be established among the pump in order to use all of them in a similar manner.

For waste water pumping stations, the pumps can be either fixed speed pumps or variable speed pumps in order to better follow the inflow.

Non return valves shall be filled in connection with each pump and dismantling valves shall be installed in order to ease the maintenance.

As far as possible the pumps shall be dry-mounted pumps. If the pumps are wet-mounted pumps, provisions shall be made for easy dismantling without emptying the structure and reinstallation shall be secure automatically.

The structures where a general by-pass must be designed for avoiding a general overflow in case of power breakdown are described in the present document.

The pumping station shall be controlled through level instruments and/or level switches. It shall systematically be fitted with a dry run protection and high-level probe for alarm.

B.3.2 Project Description

B.3.2.1 Introduction

The project description covers the 2 phases of construction:

- Phase I: Consisting of capacity extension from 140,000 m^3/d up to 282,459 m^3/d (Design year 2050) and upgrade of treatment level from preliminary to primary in addition to sludge treatment, power generation and odor control

- Phase II: Consisting of the treatment level upgrade from primary to secondary

Major components of each phase are described below:

B.3.2.1.1 Phase 1

- Preliminary Treatment Unit, to include;
  - Refurbishment, capacity extension and upgrade of Initial Lifting Station
  - Refurbishment, capacity extension and upgrade of Screening system to include additional fine screens and their ancillaries
  - Refurbishment, capacity extension and upgrade of Aerated De-gritting Chambers and their ancillaries
- New Primary Treatment Unit (Lamella settling tanks design);
- Primary Sludge Treatment Facilities, including:
  - Gravity Thickeners, for primary sludge (PS);
  - Sludge Screening, for primary sludge
  - Buffering-Mixing tanks, for PS and SAS;
  - Anaerobic Digestion Treatment, for mixed sludge;
  - Mechanical Dewatering of digested sludge;
  - Storage of dewatered sludge.
- Biogas Utilization Unit, including:
  - Biogas Collection and Storage;
  - Combined Heat - Power (CHP) Engines, for power production;
  - Emergency Gas Flaring Station.
- Odor control
- SCADA
- Electrical System and PLC
- Any ancillary units to make the works complete

B.3.2.1.2 Phase 2

- Secondary Treatment Unit, including:
  - Anoxic tanks and their ancillaries;
  - Aeration tanks and their ancillaries;
  - Secondary Settling Tanks and their ancillaries;
  - Chlorination/de-chlorination tanks and their ancillaries.
- Secondary Sludge Treatment consisting of:
  - Mechanical Thickening, for surplus activated sludge (SAS);
  - Buffering-Mixing tanks, for PS and SAS (Extension of phase 1);
  - Anaerobic Digestion Treatment, for mixed sludge (Extension of phase 1);
  - Mechanical Dewatering of digested sludge (Extension of phase 1);
  - Storage of dewatered sludge (Extension of phase 1)

- Biogas Utilization Unit, including:
  - Biogas Collection and Storage (Extension of phase 1);
  - Combined Heat - Power (CHP) Engines, for power production (Extension of phase 1);
  - Emergency Flaring Station (Extension of phase 1).
- Odor control (Extension of phase 1)
- SCADA (Extension of phase 1)
- Electrical system and PLC (Extension of phase 1)
- Any ancillary units to make the works complete

B.3.2.1.3 Operation and service facilities

The WWTP will use the Conventional Activated Sludge Process with sludge treatment, anaerobic digestion and power generation. In addition to the process equipment mentioned earlier, the following structures and facilities shall be included as a minimum:

- Influent lifting station building extension
- Treated Sewage Effluent pumping building refurbishment
- Intermediate pumping station (to transfer primary effluent to the biological treatment)
- RAS/SAS pumping stations
- Air blowers building
- Influent/effluent distribution chambers, Flow Measurement systems
- Sludge Dewatering buildings
- Sludge Stocking silos
- Services Buildings: Administration, (including Supervisory Control and Data Acquisition "SCADA" system), workshop, guardhouse, accommodation, chlorination, etc.
- Power Supply Buildings: Standby Power Generation Facilities, Transformer Room (medium/low voltage), connection to the Public Power Grid
- Landscaping, access roads inside and outside the site, mainly access road between the existing plant location and secondary treatment site.

B.3.2.2 Preliminary Treatment

All the works related to the preliminary treatment shall be designed and implemented in this contract (Phase 1)

B.3.2.2.1 Initial Lifting Station

The existing inlet lifting station is composed of the screw pumps lifting station structure including the inlet culverts and a building housing the screw pumps motors and MCC and related equipment. Prior to the Initial Lifting Station, the contractor shall design and execute a flow measurement system.

The existing lifting station contains 6 (+ 1 standby) Archimedean screw pumps, each with capacity of 440 1/s at 5.30 m head. These pumps were subject to critical repair by UNICEF to put them into operation.

The contractor shall make an assessment of the existing pumps prior to submitting his offer and propose the solution he will adopt: either conduct a comprehensive repair for the existing pumps guaranteed for the duration of operation and maintenance or replace the existing pumps by new ones.

Moreover, (6+ 1) additional screw pumps each of 440 1/s capacity at 5.30 m head shall be supplied to cater for the design flow.

The supplementary pumping station will be identical to the existing and extend on both side of the existing one as per site conditions. It will then cover the needs of the increased capacity expected during the wet season flow i.e. 5.13 m^3/s from the first year of the operation of the extended plant (2050) peak flows).

Consequent to the above-mentioned extension works the current inlet and over flow manholes (Between the receiving chamber and the screw pumps lifting station structure) shall be demolished. Therefore, new structure shall be constructed, in addition to the needed pipelines connections and accessories, permitting the following:

- Discharge the sewage overflow to the nearest existing overflow pipeline manhole.
- Reconnect the existing stormwater pipeline (DN1500mm) to the inlet culvert, upstream the screw pumps lifting station structure.

Moreover, new flow measurement structure/s shall be constructed upstream the screw pumps lifting station structure enabling to define the total influent flow. This construction shall be equipped with all the needed mechanical and electrical equipment.

Wastewater from the pumping stations is gravity-fed to the screens.

Type of Pumps: Archimedean Screw pumps

Quantity: Fourteen (14)

Number of Duty Pumps: Twelve (12)

Number of Standby Pumps: Two (2)

Pumps Capacity: 440 l/s each

Pump head: 5.3 m

Screw diameter: 1,400 mm

Flight length: 10.37 m

Tube diameter: 762 mm

Angle of Inclination: 35 °

Material of Screw: S235JR or equal

Material of Tube: S235JRH or equal

Side rail material: S235JR or equal

Cast-in steel trough material: S235JR or equal

Motor Power: 37 kW

Type of lower bearing: Eco-friendly (maintenance free) – For new pumps only

Upper bearing type: floor mounted

Design life time upper bearing: >100.000 hrs

Material lower bearing housing: cast iron GG 25 (DIN 1691)

Shaft material: cast iron GGG 60/70 (DIN 1693)

Material bushing: bronze

Surface protection:

Surface preparation: shot blasted SA 2,5

Coating system immersed parts: 2 layers coal tar free epoxy or equal DFT 300 microns

Coating system for non-immersed parts: 1-layer Amercoat 235, fast dry epoxy or equal DFT 80 microns

B.3.2.2.2 Screening And Treatment of Screening Waste

There are 5 existing rake type screens, of 40 mm bar spacing, in operation at the Al-Ghadir plant. They appear to be in very good condition; and will be maintained in operation until Phase II, mainly for the driving mechanism. It is estimated that their capacity will cover the wastewater peak weather flow up to 2050.

Additionally, 5 fine screens with 6 mm clear spacing are to be installed after the 40 mm screens, which will serve the flows of the present situation as well as the flows up to 2050. During Phase II, the existing 40 mm screens are to be replaced with new ones, as it is assumed that they will be obsolete by that time.

The screenings conveyor and screenings compactor are in bad conditions; it is recommended to be replaced.

After screening, the wastewater gravitates to the aerated grit chambers. Screenings are to be collected via belt conveyors to respective compactors, and will be disposed of as municipal wastes.

- For the fine screens:
  - Total average flow: 3.87 m3/s
  - Total peak flow: 5.3 m3/s
  - Number of channels: Five (5) (existing, can be adjusted as needed)
  - Number of screens: Five (5)
  - Clear opening: 6 mm
  - Type: Vertical or inclined (75°) bar screen
  - Material of construction: SS316
  - Minimum Approach velocity: 0.3 m/s
  - Maximum velocity through screen: 1.2 m/s (existing channels)
  - Power: 1.1 kW
- For Belt Conveyor:
  - Quantity: One (1)
  - Length: 13,000 mm
  - Width: 800 mm
  - Belt material: coated in PVC
  - Power: 0.18 kW
- For Screenings Compactor
  - Quantity: One (1)
  - Capacity: 3 m3/h
  - Nominal diameter: 400 mm
  - Power: 5.5 kW
  - Material of construction: SS316

Automatic cleaning shall be slaved to a timer and to a head loss detected system. Head loss shall be detected by a piezoresistive sensor, suspended switch or equivalent system (bubble pipe systems are prohibited).

In the event of a breakdown, headloss threshold or blockage of the cleaning system, local alarms (audible and visible) and central alarms must be set off.

Each channel shall be isolated by stop logs in order to dry the section in front of the screens.

The exceptional operation is defined as operation with one line out of operation, the remaining lines shall be capable of receiving the peak daily flow without exceeding a speed of 1.2 m/s in the screens.

All equipment, instruments and material required to make the system operational in proper manner are included in the contractor's scope.

B.3.2.2.3 Removal and Compacting of Screening Waste

All the process shall be carried out within the existing system with some adjustment as deemed necessary. Each screen channel shall be isolated by new stoplogs.

Coarse Screening shall be lifted automatically, conveyed, compacted and poured out to be stored in a container, using new compactors. Fine screenings shall be lifted automatically, conveyed and compacted prior discharged in the corresponding storing containers.

No manual operation must be required for the screening waste to fall on to the conveyance system. In this respect, the waste must be lifted to a sufficient height.

The waste may be conveyed by a belt or endless screw system.

In the case of a conveyor belt, the dripping water shall be collected along the entire length of the belt to avoid soiling the floor or walls. This recovery system must be easy to clean, either directly or after dismantling.

In the case of a screw, there must be a slight gradient to help with the removal of dripping water. A row of sprinklers shall be provided for washing the screw and trough.

The drippings from the belt or screw must return to the screening channels.

The operation of the conveyance system shall be slaved to the operation of the screening system. In the event of a break-down or blockage, local and central alarms are set off.

Screening waste shall be compacted to reach 35% dryness and then stored in a skip. The operation of the compacting system shall be slaved to the start-up of the conveyance devices. In the event of a break-down or blockage, local and central alarms are set off.

The site shall have at least 5 days' autonomous storage capacity.

Arrangements shall be made to facilitate floor cleaning (pressurized industrial water offtakes, sloping screed, floor siphons, etc.).

The exceptional operation is defined as operation with any particular equipment out of order; no specific level of treatment is required, but the following spare part shall be provided in the storage place:

- A motor for each type of conveyor belt or endless screw.
- A motor for each type of compactor.

B.3.2.2.4 Grease and Grit Removal – Treatment of Grit and Grease

There are 4 existing chambers for the removal of grit and FOG (Fat-Oil-Grease) from the incoming wastewater. Each of the existing chambers has effective volume of 240 m^3 (L x W x H is 20.0 m x 3.0 m x 4.0 m).

The existing grit chambers are aerated by 2 (+ 1 standby) common blowers with a capacity of 960 m^3/h at 0.4 bar head each. Two blowers are old blowers and one is a new replacement. All the blowers are operating in good condition.

In order to treat the flows up to 2050 within the available space, one additional grit chamber is required, with identical dimensions as the existing ones.

The existing blowers have the capacity to provide the aeration needs up to 2050.

The grit collected at the chamber will be removed by grit pumps, the capacity of each being 2.0 m^3/h at 6.0 m head. The pumps will deliver the grit to the respective grit classifiers which will finally be disposed of in containers as municipal waste. The existing grit classifier is in bad conditions and recommended to be replaced. All existing grit pumps will be replaced and one additional pump will be installed at the new de-gritting chambers.

Type of grit chamber: Aerated Grit Chamber, rectangular

Quantity: Four (4) existing + One (1) New

Total peak flow: 5.3 m^3/s

Total average flow: 3.87 m^3/s

Minimum Detention time at peak flow: 3 minutes

Air supply 0.2 – 0.5 m^3/min.m

Grit shall be recovered by bottom scraping and/or pumping by air lift, and grease by surface scrapping on bridge under a bridge travelling back and forth. The new channel shall have its new own bridge. The structure must be aerated by equipment distributing fine bubbles.

Each existing 2 channels, have a single bridge. Each channel can be isolated by penstocks. The operation of the bridges shall be slaved to the flow entering into the plant.

The walls and bottom of the structures are carefully profiled and smooth to prevent settling particles from being caught.

The exceptional operation is defined as operation with a line out of order. If one line shuts down, the line(s) remaining in operation shall be capable of ensuring grit and grease removal at average daily design flow.

B.3.2.2.5 Recovery of Grit - Dewatering – Disposal

Performance to be guaranteed

- Organic content of grit ..... <5%

Grit may be recovered by an air-lift system or by pumping from a hopper at the end of the channel or along the entire channel and poured into a chute toward a pit with a capacity of 3 operating days. A watertight manhole shall be fitted for entering into the pit.

Each channel shall have its own equipment.

In the case of an air-lift system, the suction pipes shall be fitted with tapings to introduce water under pressure.

The grit shall be exhausted from the pit and sent to an efficient washing system, using “monochannel” pumps. Efficient grit washing shall be provided so that sand can be recycled as fill material.

The choice of process shall be defined by the contractor in his proposal. The quantity of organic matter in the grit after washing is that guaranteed contractually by the contractor and must be at most 5%.

The treatment capacity shall be able to treat 2 operating days within 1 day.

The diameter of the pipe between the pit and the washing system shall be at least 100 mm.

At the end of the screw, the dewatered and washed grit falls into a removal skip. The skips shall be closed and airtight. The storage capacity on site shall be equivalent to at least two weeks' production.

The grit pit is fitted with an ultrasonic probe for high and low level accordingly with the switch control of the pumps and the grit washing equipment.

The exceptional operation is defined as operation with any particular equipment out of order; at least the equipment shall include an extra similar grit extraction pump in stand-by on the spot. The pumps shall have the same characteristics; they shall be operated manually, automatically according to a clock control.

B.3.2.3 Primary Treatment

Primary treatment of the wastewater will consist of 12 rectangular primary settling tanks for solids removal. The tanks will be equipped with lamella plates to reduce their footprint.

Each tank is designed to have a hydraulic load of minimum 6.6 $m^3/m^2/h$ and a hydraulic retention time (HRT) of around 1.0 hour resulting in an effective surface area of 7.5 x 32 = 240 m^2 and effective volume of 1,080 m^3. The primary effluent shall flow by gravity into the wet well of the Interim Lifting Station (Phase II) or to the Discharge Pumping Station / Emergency by-pass (Phase I).

Primary sludge will be collected into bottom hoppers and will be removed by sludge pumps, each with capacity of 30 m^3/h at 14.0 m head. Those pumps will be installed on top slab between the clarifiers and transfer the primary sludge to the primary sludge thickeners buffer tanks which are located in the reclaimed area. Road crossing is taken into consideration for this purpose.

The above primary treatment shall be designed and implemented in the current contract Phase 1

Also, the pumps in the Interim Lifting Station shall transfer the primary effluent to the biological tanks 'distribution located in the reclaimed area.

- Type clarifier: Rectangular, lamella type
- Number of clarifiers: Twelve (12)
- Hydraulic Retention time: ~60 minutes
- Tank volume, each: 1,080 m^3
- Tank Surface area: 240 m^2 (32 m x 7.5m)
- Side water depth: 4.5 m
- Type of lamella: Tube settlers
- Lamella inclination: 60°
- Lamella tube clear spacing: 10 cm
- Lamella material: Polypropylene, talk enforced
- Lamella to include: Support Beams and Anti-floating, material: GRP, fasteners from AISI316L
- Scraper: 2 shaft, surface scum scraping system
- Scraper chain collector : non-metallic
- Scraper accessories: flights made of GRP equipped with bottom and end rubbers, Wear shoes made of PE, Rails made of AISI316, Head shaft made of AISI316, bearings made of PE, drive sprocket made of PE, Tensioning shaft made of AISI316, Collector chain tensioning device AISI316, Drive assembly (Helical Gear Motor), Drive sprocket AISI316, Driven sprocket AISI316, Drive chain AISI304
- Steel material below water level: AISI316L

- Steel material above water level: AISI316L
- Scraper speed: approx. 1.2 m/min
- Minimum instruments to be included: Drive overload monitor, Flight parallel run sensors
- Power: ~0.25 kW

It is expected that the current flow will not exceed 140,000 m^3/d. The clarifiers tanks shall be built for flows of year 2050. At the current stage, installation of lamella settlers would not be required depending on the client's instructions. The clarifiers shall be designed to allow installation of lamella settlers in the future.

B.3.2.4 Secondary Treatment

B.3.2.4.1 General

Biological treatment consists of de-nitrification tanks, carbon and ammonia reduction tanks and final sedimentation tanks, with a recycle for de-nitrification. The biological treatment is to be divided in 12 operational lanes, as described below. The secondary treatment shall be constructed at Phase II for ultimate flow (year 2050 flow).

An interim pumping Station shall transfer the primary effluent to the secondary treatment stage.

To be noted that all the works related to the secondary treatment, mentioned in this section, shall be duly designed in the present contract. However, the construction of these works will be implemented in other separate contract (Phase 2), except the construction of the interim pumping station, flowmeter chamber and valves chamber (without the process equipment) which will be achieved in this contract (Phase 1)

B.3.2.4.2 Interim Pumping Station

Wastewater from the lamella primary settlers will overflow into the interim lifting station wet well, which will pump it to the biological treatment basins distribution unit located in the reclaimed offshore area.

The interim lifting station will consist of a set of 12 dry type pumps in operation (+6 standby installed), each with capacity of 1,590 m^3/h at 10 m head. The pumping station shall consist of wet well, dry well as pumps house and a ground floor level building, an area of 650m^2 and a total height of 10m (~ 4.5m above ground).

Two (2) pipes DN1400 shall be used for this purpose. Road crossing shall be considered. Each pipe will have its own flowmeter and isolation gate valve.

Type of pumps: Submersible sewage pumps, dry installation

- Quantity of duty pumps: Twelve (12)
- Quantity of standby pumps: Six (6)
- Capacity: 1,590 m^3/h at 10 m head
- Power: 60 kW
- Number of poles: Six (6)

B.3.2.4.3 Biological Treatment Basins

A distribution box shall receive primary effluent from the Interim pumping station and distribute it to Twelve (12) biological treatment basins which have a total liquid volume capacity of 270,720 m^3. Each biological treatment basin will be subdivided into different zones, each having different process functions comprising:

- Anoxic Zones; and

- Aerobic Zones.

The wastewater organic pollution and ammoniacal nitrogen will be removed by biological oxidation using freely suspended biomass (mixed liquor) in the aerobic zones. Some of the nitrate produced will be converted to nitrogen gas by denitrification via the biomass in the anoxic zones.

Each treatment lane will have two anoxic pockets. The two pockets will have effective volume of ~3,840m^3 (L x W x H is (2x16.0) m x 20.0 m x 6.0 m and will be equipped with 2 submersible mixers of minimum power input of ~18.5 kW (each mixer in each pocket) to keep the biomass suspended without introducing air. A total of 24 installed mixers and an additional 4 non-installed spare mixers will be provided.

From the anoxic zone the wastewater and mixed liquor will gravitate through three aerobic pockets per lane. The aerobic pockets will biologically oxidize the wastewater's organic load and nitrify the ammoniacal nitrogen. The aerobic pockets are designed to allow for 12 days sludge retention time (SRT), thus the total effective volume of the aerobic zone per lane will be ~18,720 m^3 (L x W x H = (3x52.0) m x 20.0 m x 6.0 m and will be designed to provide plug flow (see relevant layout drawing) to prevent filamentous biomass growth.

All 12 aeration zones will be aerated through 16 blowers (plus 2 blowers on standby) which will be installed in a building with dimensions L x W x H = 30.0 m x 8.5 m x 5.0 m. Each blower will have a capacity of 14,732 m^3/h at 7.0 m head. The air will be supplied in the aerobic zones of each lane via fine-bubble disc diffusers. The total number of disc diffusers required for the aeration is 235,712m^3/h, which are divided across the 12 lanes (19,642 diffusers per lane).

Furthermore, the mixed liquor at the end of each aeration zone will be recycled using wall propeller pumps to the respective anoxic zone at the start of the lane. Each lane basin will have 3 recycle pumps, 2 duty and 1 installed standby, each rated for 910 m^3/hr at 0.8 m head. A recycle ratio of approximately 1.5 times the sewage feed will be used to achieve the nitrogen related discharge limits, by providing nitrate to the anoxic zones for denitrification.

After passing through the aerobic zone, the mixed liquor will then gravitate to the mass/liquid separation unit, the Final Settling Tanks (FSTs).

- For anoxic zones
  - Number of trains: Twelve (12)
  - Compartment in each train: Two (2)
  - Hydraulic Retention Time: 4 h
  - Total Anoxic Volume: 46,080 m^3
  - Volume per train: 3,840 m^3
  - Compartment width: 20.0 m
  - Compartment Length: 16.0 m
  - Train length: 32 m
  - Water Depth: 6 m
  - Number of mixers per: One (1)
  - Mixer Power: 18 kW
- For aerobic Tanks
  - Type of Biological Process: Conventional Activated Sludge Process
  - Number of trains: Twelve (12)
  - Design MLSS: 3,000 mg/L

- Dissolved Oxygen in bioreactor: 2 mg/L
- Solids Retention Time: 12 d
- Type of diffusers to be used: Fine bubbles diffusers
- Diffuser Oxygen transfer efficiency: 32%
- Aeration factor Alpha (α) – Nitrification: 0.65
- Relative DO saturation to clean water (β): 0.95
- Hydraulic retention time at 30° C: 17 h
- Total tanks volume: 224,640 m^3
- Water Depth: 6 m
- Train Width: 20.0 m
- Number of compartments per train: Three (3)
- Compartment Length: 52 m
- Train Length: 156 m

B.3.2.4.4 Final Settling Tanks

The final settling tanks are used to complete the biological treatment of sewage, by separating the produced biomass from the liquid.

It is recommended that Twelve (12) circular FSTs are constructed for clarification of the treated effluent. Each FST is designed to have hydraulic load of 1.2 $m^3/m^2/h$, resulting in an effective surface area of 1,256 m^2 (diameter: 40.0 m) at ~4.0-4.5 m side water depth. Each tank is designed as sloped bottom (1/12) and will be equipped with a respective rotating bridge to allow the collection and removal of scum and settled sludge.

Recirculation of the sludge back to the anoxic pockets of each lane will be performed by 12 pumps (+6 standby) with each pump having a capacity of 610 m^3/hr at 6.0 m head, while for the removal of the surplus activated sludge (SAS), 6 pumps (+6 standby) rated for 90 m^3/hr at 10 m head will be used.

- Quantity of Clarifiers: Twelve (12)
- Type of clarifier: Circular, half bridge rotating scraper
- Drive type: Peripheral drive
- Overflow rate at average flow: 20 $m^3/m^2.d$
- Overflow rate at peak flow: 30 $m^3/m^2.d$
- Solids loading rate at average flow: 5 $kg/m^2.d$
- Solids loading rate at peak flow: 8 $kg/m^2.d$
- Weir loading rate: 250 $m^3/m.d$
- Hydraulic retention time: > 4 hours
- Clarifier diameter: 40 m
- Water depth: 4.5 m
- Drive power: 0.75 kW
- Peripheral speed: ~2 m/min

B.3.2.5 Chlorination and De-Chlorination

The clarified effluent from the FSTs will overflow to the chlorination tanks where Sodium Hypochlorite (NaOCI) 15% solution will be added for the disinfection of the effluent prior to the sea discharge.

To be noted that all the works related to the chlorination and de-chlorination, mentioned in this section, shall be duly designed in the present contract. However, the construction of these works will be implemented in another separate contract (Phase 2).

It is recommended that Three (3) tanks are constructed for this purpose, each with dimensions L x W x H = 50.0 m x 15.0 m x 3.0 m. Each tank is designed to have three lanes of 5.0 m width (serpentine flow), in order to obtain a L/W ratio of 30:1 and HRT of more than 20 minutes. Each tank will be equipped with one dosing pump (+1 standby) with a capacity of 0-150 liters/hr at 5.0 m head. The NaOCI solution will be stored in a 7m^3 storage tank within the Chemical Storage Building (dimensions L x W x H = 15.0 m x 9.0 m x 6.0 m).

Provision will be made for the last 1.0 m of each meander tank to be used for de-chlorination of the treated effluent prior to its discharge to the sea. For this purpose, one dosing pump (+ 1 standby) is used per tank to add $NaHSO_3$ 38% solution to the chlorinated effluent. Each pump will have capacity of 0-90 liters/hr at 5.0 m head and the $NaHSO_3$ 38% solution will be stored in a 42 m^3 tank located in the Chemical Storage Building.

After the de-chlorination tank, the effluent will overflow to the existing emergency outfall (500m long) from where it will discharge by gravity to the sea.

B.3.2.6 Sludge Treatment

B.3.2.6.1 Principle

It includes thickening plus anaerobic digestion plus dewatering plus lime treatment. The design shall include independent lines of treatment, starting up at the origin of the sludge up to the storage. All the transfers between the origin, each step of the process and the skip shall be automatically driven.

The only shared equipment could be the lime tank, but in this case, one screw pump per line shall be installed.

The design must include the necessary buffer storage for the process to operate.

The “normal” means of evacuation will be the landfill.

Extracted sludge comprises both primary sludge and biological sludge. This sludge shall be mixed in homogenization tanks before being treated.

The sludge treatment equipment shall be to be designed so that the workshop can operate 7 days a week with an operator present no more than 10 hours a day.

The capacity and organization of the sludge process (including storage, etc.) should be sufficient for all the sludge to be treated during the above operating times, in all load situations specified by the present performance specifications.

The works related to the sludge treatment, mentioned in this section, shall be duly designed in the present contract. However, part of them will be implemented in this contract (Phase 1) while the remaining will be constructed in another separate contract (Phase 2), as will be noted below where appropriate.

B.3.2.6.2 Gravity Thickening of Primary Sludge

The primary sludge from the lamella Primary Settling Tanks (PSTs) will be pumped to the gravity thickeners, where the sludge will be settled to thicken to a dry solids content of ~6%. Three (3) gravity thickeners are designed based on a solid loading rate (SLR) of up to 100 kg DS/m^2/day, which results in an effective surface area of ~255 m^2 (at a diameter of 18.0 m) for each.

Each thickener will be equipped with a rotating bridge to allow the collection and removal of scum and thickened sludge from its bottom. Additionally, it will be equipped with 2 thickened sludge pumps (one as standby) each with capacity of 30 m^3/hr at 6.0 m head and with 2 more pumps (one as standby) for the pumping of supernatant liquor back to the entrance of the PSTs, each rated for 30m^3/hr at 5.0 m head.

- Quantity of Thickeners: Three (3)
- Type of thickener: Picket type, full fixed bridge
- Solids loading rate: 100 kg/m^2.d
- Thickener diameter: 18 m
- Water depth: 4.5 m
- Bottom slope: 1/8
- Scraper load (design): 500 Nm
- Torque: 20500 Nm
- Drive power: 0.18 kW
- Peripheral speed: 3.6 m/min
- Rotation: ~0.0637 rpm
- Lifetime of bearings: 50,000 hrs
- Enclosure rating: IP55
- Isolation Class: F
- Construction of the thickener: The mechanical for the thickener in principle consisting of:
  - bridge across the common tank diameter;
  - thickening mechanism and bottom scraper;
  - drive unit;
  - influent well;
  - deflection plate;
  - overflow weir;
  - scum removal (surface) scrapers
  - scum board (baffle);
  - brush for the effluent channel;
  - scum box;
  - electrical supply.
- Type of the scraper and thickener mechanism: The construction of the scraper mechanism shall be designed, to deliver the settled sludge to the central sludge pit, every full rotation of the scraper mechanism. The scraper mechanism is designed to have a minimum effect to the settlement process.
- Bridge construction
  - Shape of the bridge: profile
  - Dead load: 500 N/m

  - Length: 18,6 meters
  - Walkway: galvanized gratings
  - Railings: layer tube, post strip, post (center to center) 1250 mm, height 1100 mm, provided with a knee-rail.
  - Width walkway: approx.900 mm.
  - Access ladder: galvanized, non-skid stairsteps
- Scraper a picket fence mechanism
- Central pipe shaft: A tubular center shaft connected to the shaft of the drive-unit. The center shaft shall be established by a floor mounted bearing to ensure concentric rotation. The shaft shall be constructed of steel pipe.
- Scraper arms: two scraper arms connected to the center shaft, built up of sleeve sections provided with:
  - removable thickening bars, made of tube: Center to center 600 mm.
  - Bottom scrapers placed Staggered with height max. 200 mm length 1200 mm, Angle with radius is 45º.
- Central Scrapers Two central scrapers shall be connected with the Scraper arms on behalf of the off-take pit.
- Influent Well:
  - Diameter: 1800 mm.
  - Height: 1200 mm.
  - Thickness: 4 mm.
  - Construction: divided in segments.
  - Mounted: with profiles adjustable to the bridge, topside influent well
- Weir:
  - Type of weir: V-notch, single overflow
  - Height: 200 mm.
  - Thickness: 3 mm.
  - Mounting: embedded rail and bolts
  - Sealing: sealing tape between weir and concrete.
- Materials:
  - Bridge: Mild steel
  - Railings: Mild steel
  - Access-ladder: Mild steel
  - Bottom bearing: AISI 316
  - Scraper arms: AISI 316
  - Influent well: AISI 316
  - Central scraper: AISI 316
  - Inlet pipe

- Weir: AISI 316

- Coating:
  - Steel parts: Hot dip galvanized
  - Stainless steel: pickled

All the above thickening activities shall be implemented in this contract (Phase 1)

B.3.2.6.3 Sludge Screening

In order for any large material that has passed through the wastewater screens (and settled with the primary sludge) to be removed from the primary sludge, the thickened primary sludge will be pumped through Three (3) sludge screens. These screens will have openings up to 3.0 mm. After the screens the sludge ends up to the buffer tanks (Buffer Tanks I) prior to anaerobic digestion.

- Type: Continuous cleaning screen filter
- Quantity: Three 93)
- Operation: Automatic
- Capacity: 30 m^3/hr
- Mesh: 3 mm
- Filtering screen: Perforated Plate
- Entry pipe: DN100
- Exit pipe: DN125
- Construction materials
  - Frame and body: AISI316
  - Filtering cylinder: AISI316
  - Filtering cylinder reinforcement and lids: AISI316
  - Filtering cylinder driving axis: AISI316
  - Back shutting element: EPDM grease resistant
  - Side shutting element: PE, HD-100
  - Solid scraper: alloy brass
  - Scraper springs: AISI316
  - Body and frame support legs: AISI316
  - Spraying mouth: Alloy brass
  - Rolling: NSK or similar
  - Solids conduction ramp: AISI316
  - Bolts and screws: AISI316/A4
- Gearing drive:
  - Type: Crown endless
  - Entry speed: 15 RPM
  - Service factor: 1.8
- Engine drive

- Power: ~0.25 kW
- Entry speed: ~1410 RPM

- Accessories: Washing electro valve, Torques switches, Control panel

All the above thickening activities shall be implemented in this contract (Phase 1)

B.3.2.6.4 Mechanical Thickening of Surplus Secondary Sludge

The surplus secondary sludge will be pumped to a buffer tank (Buffer Tank II) prior to the mechanical thickeners. The buffer tank will have an effective volume of 2,281 m^3 (diameter: 22.0 m, height: 6.0 m) which allows for more than 6 hours hydraulic retention of the secondary sludge prior to the feeding of the thickeners.

Six (6) closed drum type thickeners (and one standby) will be used for this purpose, each with capacity of 90 m^3/hr, installed in the secondary sludge thickening building.

Each drum thickener will be equipped with the respective feeding pump (86 m^3/hr at 5.0 m head) the respective polyelectrolyte dosing pump (0-10 liters/hr at 5.0 m head) and the respective thickened sludge pump (12 m^3/hr at 30.0 m head). Also, 2 pumps (+1 standby) each rated for 149 m^3/hr at 5.0 m head, will be used to return supernatant leachate back to the denitrification basins.

The polyelectrolyte solution will be prepared in a system consisting of preparation tanks and mixers and will be located within an adjacent building.

After thickening the secondary sludge will have a solids-content of ~6% and will be pumped to the thickened sludge buffer tanks (Buffer Tanks I) prior to digestion.

The above mechanical thickening of secondary sludge shall be implemented in another separate contract (Phase 2)

B.3.2.6.5 Anaerobic Digestion

Both thickened primary and secondary sludge will be mixed in the buffer tanks prior to anaerobic digestion. Two buffer tanks will be constructed, one in Phase 1 and another one in Phase 2, each with an effective volume of 302 m^3 (diameter: 8.0 m, height: 6.0 m) to allow a sludge retention time of 6 hours prior to the anaerobic digestion.

The mixed sludge will then be introduced to the anaerobic digesters. The digesters will operate with a sludge retention time of 15 days at a temperature of 35 °C, in order to stabilize the sludge and transform any volatile compounds into biogas. Accordingly, Four (4) anaerobic digesters will be constructed each with an effective volume of 8,675 m^3 (diameter: 23.5 m, height: 20.0 m).

Each digester will be equipped with 1 feeding pump (+1 standby) rated for 24 m^3/hr at 22.0 m head, with a mixing system with minimum power input of 30 kW and with 1 recirculation pump (+ 1 standby) rated for 48 m^3/hr at 20.0 m head.

After the digestion tanks the sludge will be collected in the buffer tanks (Buffer Tanks III) prior to the dewatering process.

During Phase I, the biogas produced at the digesters will be collected by the use of 4 (+2 standby) biogas blowers rated for 250 m^3/hr at 5.0 m head and stored at a steel spherical tank of 4,500 m^3 effective volume.

This tank is designed to allow biogas storage for ~2 hours. In Phase II, three additional blowers (1 as standby) will be installed to cover the increase in biogas produced.

All pumps and blowers will be located within a separate concrete structure with dimensions L x W x H = 15.0 m x 10.0 m x 6.0 m.

In addition, an access structure shall be constructed, comprising stairs case and lift and steel structure permitting the access between the stairs case upper level and the anaerobic digesters.

To be noted that two anaerobic digestors and the access structure shall be constructed in the current contract (Phase 1), including the needed process equipment, while the remaining 2 anaerobic digestors will be implemented in another separate contract (Phase 2).

The digesters shall be equipped with, but not be limited to:

- Sludge mixing system, explosion proof, flame arrestor
- Gas draw-off and injection piping
- Sludge feed, draw-off, effluent and circulation piping
- Sludge heat exchanger
- Gas compressors, explosion proof
- Overhead girder crane
- Digester emptying pumps
- Gas filter station
- Biogas desulphurization system
- Biogas power and/or heat generation system
- Radar sludge/foam level measurement

The gas holding tanks shall be equipped with, but not be limited to:

- Biogas level indicator
- Biogas piping including isolating valves, control valves and flow meter
- Condensate drain
- Pressure and vacuum release valve
- Gas alarm system, flame arrestor

The gas flare system shall be equipped with, but not be limited to:

- Hidden gas flare with automatic ignition system
- Biogas piping including isolating valves, control valves and flow meter
- Gas alarm system, flame arrestor

The boiler room shall be equipped with, but not be limited to:

- Biogas and diesel fired boiler units
- Boiler water make-up plant
- Gas, diesel, boiler water piping including isolating valves, control valves and flow meter
- Boiler water pumps
- Sump pump
- Spare units for at least 50 % of the plant capacity
- Overhead girder crane
- Gas alarm system, flame arrestor

The access structures to the top of the digesters shall consist of staircase and industrial access lift. The access lifts shall be designed to ensure safe and efficient access for maintenance and inspection. Here are some general specifications to consider:

1. Load Capacity: The lift should be able to support the weight of maintenance personnel and their equipment. The load capacity shall be 1000 kg.
2. Lift Height: The lift should reach the top of the anaerobic digester. If it is not possible due to restriction in height (envelop) as imposed by the directorate of civil aviation, the contractor shall use the maximum possible lift height and complement by an access staircase.
3. Safety Features: Include safety rails, emergency stop buttons, and non-slip platforms to ensure the safety of personnel.
4. Material: The lift should be made of corrosion-resistant materials, (Stainless steel) to withstand the harsh environment of a wastewater treatment plant.
5. Power Source: Provide continuous power source
6. Certification: Ensure the lift complies with relevant safety and industry standards

This item (lift) shall consist of supplying, transporting, storing, installing and testing a lift as shown and specified including:

- Cabin
- Landing doors and door frames
- Hoist drive machine with electric motor
- Gearbox, drive sheave, and handwheel
- Bedplate and shock-absorbing rubber pads
- Shaft equipment including guiderails, suspension ropes, speed governor ropes, safety gear and speed governor, buffers, counterweight
- Safety equipment including emergency unlock of landing doors, emergency hand-winding equipment, landing and cabin door interlocks, overrun and speed limit switches, emergency cabin light and alarm supply, overload indication and protection, slipping rope protection, toe guard
- Digital position indicator
- Call push buttons
- Electrical panelboard including controller, protection and control devices
- Connection of electrical feeder and protective earth

B.3.2.6.6 Digested Sludge Buffer Tanks Prior To Dewatering

Buffer tanks (Buffer Tanks III) will be used to provide sufficient time for the digested sludge to cool and be degassed (from residual gasses from the digestion process). Two (2) tanks will be considered in the design, which are to designed based on a HRT of 5 days. Each tank will be equipped with an aeration system to facilitate degassing of the digested sludge. The aeration system will consist of 2 blowers (+1 standby) rated for 5,638 m^3/hr at 6.0 m head and coarse bubble diffusers.

One buffer tank shall be constructed in the current contract (Phase 1), including the needed process equipment, while the other buffer tank will be implemented in another separate contract (Phase 2).

B.3.2.6.7 Sludge Dewatering

After the buffer tanks, the digested sludge is to be fed to the mechanical dewatering unit. In Phase I, the mechanical dewatering unit will consist of 3 (+ 1 standby) centrifugal dewatering machines (centrifuges) each with 60 m^3/hr capacity, feeding pumps (each rated for 50 m^3/hr at 5.0 m head), polyelectrolyte dosing pumps (each rated for 0-20 liters/hr at 5.0 m head) and dewatered sludge pumps (each rated for 8 m^3/hr at 12.0 m head). The supernatant liquor is to be pumped into the primary settling

tanks by 2 (+2 standby) pumps (each rated for 57 m^3/hr at 6.0 m head). In Phase II, Two (2) additional sets of centrifuges (centrifuge- feeding pump- dosing pump- sludge cake pump) will be installed.

- Type: Decanter Centrifuge
- Quantity: 3 duty + 1 standby (Phase I)
- Capacity: 60 m^3/hr each
- Installation: Indoor
- Material of Construction:
  - Bowl: Duplex SS 1.4162 or equivalent
  - Scroll: SS316/316L
  - Other wetted parts: SS316/316L
  - Bolt and nuts: A4
  - Frame: Painted carbon steel
  - Covers: Bowl cover: GRP, Drive cover: GRP
  - Paint for part in Cast Iron or steel: As per manufacturer's standard
- Rotor:
  - Maximum speed: 3000 RPM
  - Pend depth adjustment: Turbojet Sliding weir plates
- Wear protection:
  - Inner bowl surface: Grooves
  - Scroll flight: Tungsten carbide
  - Feed chamber (scroll): Cast iron bushings
  - Solids discharge (Bowl): Cast iron bushings
- Seals and lubrication:
  - Seals: NBR
  - Main bearing lubrication: Grease Lubrication
  - Thrust bearing lubrication: Grease Lubrications
- Drive System:
  - Type: Double frequency variation: Bowl and Conveyor are adjustable via VFD during operation
  - Main motor: 75 kW – 4 poles
  - Secondary motor: 22 kW – 4 poles
  - Differential speed range: 1 – 15 RPM
  - Reducer (gearbox)
- Motor:
  - Efficiency class: IE4
  - Voltage, frequency: 380 V +/- 5% / 50 Hz +/- 2%

  - Protection/Insulation class/Heating class: IP55/F/B
  - Main motor instrumentation: Temperature sensor 1xPTC/Windings
  - Secondary motor instrumentation: Temperature sensor 1xPTC/winding
- Variable Frequency Drive:
  - Protection: IP20
  - Communication to control module: Profinet
  - Ambient conditions: to be installed in a separate air ventilated room
- Vibration level: 4.5 mm/s
- Wash water flowrate: 15 30 m^3/hr
- Special tools to be provided
- Temperature monitoring:
  - Number of Probes: 2
  - Measurement parameters: Bearing temperature
  - Output function: 4 – 20 mA
  - Protection class: IP67
  - Housing material: SS 1.4404/PA PACM 12
- Vibration sensors:
  - Number of probes: 2
  - Measurement parameters: Frame velocity in mm/s
  - Output function: 2 x digital PNP / 1 x 4 – 20 mA
  - Protection class: IP67
  - Housing material: SS 1.4404/PBT / PC / FPM
- Accessories to be provided: PLC control system, 10 inches colored HMI, communication,

The dewatered sludge will be pumped and stored for a week to the dewatered sludge silos. Four rectangular silos (2 for phase I, 2 for phase 2) have been designed for this purpose, each with dimensions L x W x H = 10.0 x 7.5 x 12.0 m.

The sludge shall be removed by trucks

B.3.2.6.8 Sludge Storage Silos (for Phase I)

Type: rectangular

Dimensions: L15 x W10 x H12 m (2 units)

Storage capacity: One (1) Week

Silos construction: Reinforced concrete

The silos shall be equipped with sliding frame, slowly reciprocating, hydraulically driven steel frame pushes or pulls sludge toward a central extraction screw. It shall be speed controlled to provide out loading rates suitable for fast truck filling down to pump feed. It shall allow for vertical walls, optimizing volume utilization with capability of reducing height or footprint. It shall eradicate any opportunity for bridging, arching or flow hang ups – material flow is first in, first out. It shall provide

reliable, quiet and simple operation and can be applied to rectangular silos, concrete bunkers, and truck receival bunkers.

B.3.2.6.9 Lime Treatment

Lime treatment by mixing the dewatered sludge with quicklime.

The equipment includes in particular:

- lime silo(s), to ensure at least 21 days' autonomous storage, calculated on the basis of maximum consumption,
- 1 mixer and a screw conveyor per line.

No particular provision is made for exceptional operation, except to provide 1 screw pump per line a stand-by mixer in the storage place.

Each screw pump shall be able to treat the peak situation sludge in less than 16 hours.

B.3.2.6.10 Biogas Utilization

The biogas produced from the anaerobic process will be utilized by Combined Heat-Power (CHP) engines, in order to produce electricity, which will cover significant part of the plant's power and heating needs. For this purpose, biogas from the steel spherical storage tank will be fed to 3 CHP engines (2 in Phase I and one in Phase II), each rated at an electrical output power of 888 kW.

In addition to the CHP engines, a gas flaring station will be installed for safety reasons (Phase I), in order to burn the biogas in situations when the CHP engines are out of operation (malfunction, maintenance, etc.). During Phase II, an additional gas flaring station will be installed.

Moreover, for the initiation of the anaerobic digestion process, auxiliary boilers will be used to heat the sludge.

Quantity for Phase I : Two (2)
Capacity each : 888 kW
Heat Recovery : From exhaust
Radiator : Remote
Master Panel for parallel operation : included – from manufacturer
Emission values : NO_x < 500 mg/Nm³ (5% O_2) | < 190 mg/Nm³ (15% O_2)

		100%	**75%**	**50%**
Power input	kW	2,622	2,015	1,421
Gas volume	Nm³/h	437	336	237
Mechanical output	kW	1,095	821	548
Electrical output	kW el.	1,067	799	531
Heat to be dissipated (calculated with Glycol 37%)				
	kW	177		
~ Intercooler 2nd stage (Low temperature circuit)	kW	91		
~ Lube oil (Engine jacket water cooling circuit)	kW	126		
~ Jacket water	kW	345		
~ Surface heat	kW	85		
Spec. fuel consumption of engine electric	kWh/kWel.h	2.46	2.52	2.68
Spec. fuel consumption of engine	kWh/kWh	2.40	2.45	2.59
Lube oil consumption	kg/h	0.33	~	~
Electrical efficiency		40.7%	39.7%	37.4%
Fuel gas LHV	kWh/Nm³	6		

B.3.2.7 Nuisance Treatment

B.3.2.7.1 Odor Control

3.2.7.1.1 Principle

Due to the possibility of odor incidents occurring on site, and the proximity of the WWTP to Beirut Airport, each WWTP site will be equipped with an odor control system, which will abate odor emissions.

In the current contract - Phase 1. odor control systems shall be designed for both phase I and phase II and two odor control buildings will be constructed, one in the existing WWTP site and one in the New WWTP site.

The equipment related to phase 1, in both existing and new WWTP sites, will be implemented in this contract – Phase 1, while the remaining equipment related to Phase 2 shall be provided in another separate contract – Phase 2

The odor control system will use biological trickling filter with structural media for the oxidation of volatile odorous substances in the off-gases from the following units:

- Preliminary Treatment Unit: all existing and new works (lifting pumps, screens, grit chambers and auxiliaries) will be enclosed and connected to the odor control system;
- Primary Settling Tanks: the tanks will be covered and connected to the system;
- Gravity Thickeners: the tanks will be covered and connected to the system;
- Anaerobic Digesters;
- Sludge Screens;
- Buffer tanks (prior to mechanical thickening, to digestion and to dewatering);
- Mechanical drum thickeners;
- Mechanical Dewatering Unit;
- Dewatered sludge silos.

The total extracted air flow must take into account a sufficient renewal rate to avoid any health risks for staff and to prevent corrosion risks in covered parts; at least the hourly air renewal ratio shall be reached as indicated in Table 3-2

Closing, roofing and foul air extraction must be provided for all the facilities of the treatment plant. As far as possible, odors must be confined and exhausted as much as possible, so as to prevent them spreading in the operating rooms:

- screening waste and drainage tables must be covered,
- waste, grit and sludge skips must be closed and airtight,
- channels must be covered.

3.2.7.1.2 Airduct Network

Noxious gas detectors are obligatory on each line in “preliminary treatment” and “sludge” buildings. Any alarm automatically triggers the compulsory operation of the standby ventilation system.

The air intakes shall be installed in each place; they shall be “aluminum adjustable type” with manual register. The air speed in the airducts shall be in the range of 8m/s to 15m/s. Each low point shall be fitted with manual draining and on each main collector, some sampling points are installed. Each airduct section could be installed and dismantled with flange joints.

The air aspiration is provided by fans; if necessary, the Contractor shall design and install intermediate fans.

Insufflation of fresh air in each place is made by fans or autonomous thermal unit through grilles fitted with protections for raining water and insects.

The incoming fresh air flow shall not overpass 80% of the nominal polluted treated air flow in order to maintain all the place in a slight depression; however, the sizing of the grilles, fans or autonomous thermal unit shall be made on the basis of the extracted air.

Particular care and provisions if necessary are taken for avoiding the risk of condensation in the places where exist waste water free surfaces.

B.3.2.7.2 Bio-Trickling Filter

The air treatment system shall be of the bio-trickling filter type.

The installation shall include minimum 2 parallel independent lines of treatment, beginning at the unique air polluted reception chamber up to the discharge to the atmosphere.

Each line shall include:

- GRP towers with discharge stack and appurtenances
- Structural media
- Recirculation pumps set
- Water panel for dosing of nutrients
- Nutrients tank
- Control Panel
- Piping and accessories
- Feeding fans (one duty, one standby) is SS316 which shall take the polluted air in the reception chamber

Particular provisions shall be taken for removing the towers if necessary; a manhole shall be provided for entering in the tower. The diameter of the towers shall be such that the air maximum speed shall not exceed 2 m/s.

The odor treatment building, in addition to the odor treatment equipment for the primary treatment and sludge treatment shall be constructed in Phase 1, while the odor treatment equipment for the secondary treatment will be implemented in Phase 2.

The design criteria and characteristics of the odor control systems are shown is Table 3.2.

Table 3-2 Odor Control Systems Criteria

										Phase I		Phase II	
SN	**Description**	**QTY Ph I**	**QTY Ph II**	**Air changes per hour**	**Length or dia (m)**	**Width (m)**	**Freeboard (m)**	**Volume (m^3)**	**Total Air Flow (m^3/hr)**	**System I m^3/hr**	**System II m^3/hr**	**System III m^3/hr**	**System IV m^3/hr**
1	Outfall Pumping Station Wet Well	2		12	12.2	7	4	683.2	8,198.4	8,198.4			
2	Interim Pumping Station Wet Well	0	2	12	6	15.5	4	744.0	8,928.0				8,928.0
3	Lifting Station (Screw pumps)	12		8	11.5	1.75	1	241.5	1,932.0	1,932.0			
4	Screens channel (Overall dimensions)	1		8	10	12	0.8	96.0	768.0	768.0			
5	Grit Removal Tanks (overall dimensions)	1		8	20	36	0.8	576.0	4,608.0	4,608.0			
6	Primary Clarifiers	12		8	33.4	7.5	0.8	2,404.8	19,238.4	19,238.4			
7	Gravity Thickener - Primary Sludge	3		8	18		1	763.4	6,107.3		6,107.3		
8	Thickened Sludge Pumps and Screens Building	1		12	14	7	4	392.0	4,704.0		4,704.0		
9	Buffer Tank I	1	1	8	8		1	50.3	402.1		402.1	402.1	
10	Buffer Tank II	0	1	8	22		1	380.1	3,041.1			3,041.1	
11	Buffer Tank III	1	1	8	35		1	962.1	7,696.9		7,696.9	7,696.9	
12	Sludge Dewatering Building	1		12	25	15	4	1,500.0	18,000.0		18,000.0		
13	Secondary Sludge Thickening Building		1	12	21	12	4	1,008.0	12,096.0			12,096.0	
									Total	**34,744.8**	**36,910.3**	**23,236.1**	**8,928.0**

B.3.2.7.3 Noise

Noisy machines, centrifuges and compressors, must be covered, so that the noise level in the technical equipment rooms never exceeds the values given in chapter 2 of the present performance specifications.

The technical equipment rooms themselves must be soundproofed (soundproofing of walls, doors and windows, sound traps on all air intakes).

B.3.2.8 Covers for Tanks

This technical specification is related to the design, production of Aluminum flat covers for the control of the odors in the following sections:

- Inlet Archimedean Screw Pumping station (14 screw pumps), each pump channel 11.5x1.75 m.
- Screen and screenings channel, each 1.6 m width x L 9.5 m, QTY = 5
- Grit Removal Tanks, W 14 x L 20.5 x QTY=2 and W7 x L 20.5 m x QTY=1
- Rectangular Primary Sedimentation Tanks, each consisting of 6 lanes, each lane 7.5 x 32 m, QTY=2 (total 12 lanes)
- Primary Sludge Gravity Thickener diameter 18 m, H= 5 m, QTY = 3
- Buffer Tank I, diameter 8 m, H= 6 m, QTY=2 (1 in Phase 1 and 1 in Phase 2)
- Dewater Sludge Silos, LxWxH = 10 x 7.5 x 12 m, QTY = 4 (2 in Phase 1 and 2 in Phase 2)
- Buffer Tank III, Digester Sludge prior to dewatering, diameter 35 m, H=5m, QTY =2 (1 in Phase 1 and 1 in Phase 2)
- Buffer Tank II, Prior to sludge thickening, diameter 22 m, H=6 m, QTY = 1 (In Phase 2)

Almost all of the required covers shall be installed in phase 1, while some of them will be provided in Phase 2, as indicated above.

All the materials included in this project must be made of Aluminum alloys especially studied to avoid any corrosion and warranty a long duration and stainless Steel. The supplier must warranty all the materials for a period of 15 years vs. the corrosion.

The covers must be calculated for the following loads and characteristics:

- Wind load: 130 km/h
- Snow load: 100 kg/sqm.
- European rules for Aluminum Production: Designed following the Eurocode 9
- Inalterable from solar effects
- Maximum odor containment
- Walkable
- Easly dismantlable by hands

The technical characteristics of our Aluminum Covers and trusses are the following:

- All the materials supplied are in Aluminum alloys and Stainless Steel prefabricated
- The Aluminum flat panels, removable and walkable are built in Aluminum alloy 5754-H32, minimum thickness 2,5 mm for a maximum panel length of 8 meters.
- The beams are built in Aluminum alloy 6060 and 6063
- All the bolts are in 316 SS/ A4
- The seals are in EPDM or similar.

B.3.2.8.1 Archimedean Screw Pumps Covers

Design and supply of Aluminum Flat Covers for the n. 14 Archimede Screw Pumps with sizes 11,5 x 1,75 mt. for a total cover surface of 282 sqm.

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 1,95 mt.
- Flat panel width: 815 mm
- Flat panels height: 120 mm
- Flat panels weight: 18 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls min. 10 cm each side
- Sealing of the odors: angular profiles inferior 120 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 14 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.2 Screening Channels Covers

Design and supply of Aluminum Flat Covers for the n. 5 Screening Channels with

unitary sizes 1,6 x 9,5 mt. for a total cover surface of 76 sqm.

- Type of covers: Aluminum flat checkered plates
- Material: Aluminum alloy 5754 H 111 – minimum thickness 3 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 1,7 mt.
- Flat panels width: 1 mt.
- Flat panels height: 3+2 mm
- Flat panels weight: 16 kg each
- Flat panels shape: checkered plates interlocked with each other
- Flat panels loaded on the external concrete walls min. 5 cm each side
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 5 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.3 Grit and Grease Tanks Covers

Design and supply of Aluminum Flat Covers for the n. 5 Grit and Grease tanks with sizes: n. 2 (14 x 20,5 mt.) and n. 1 (7 x 20.5 mt.) for a total cover surface of 718 sqm

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm

- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 3 mt.
- Flat panel width: 815 mm
- Flat panels height: 120 mm
- Flat panels weight: 27 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the internal Aluminum beams fixed inside the tanks
- Internal beams: square pipe 6060 T 5 thickness 5 mm fixed inside the walls with aluminum welded plate thickness 10 mm.
- Number of beams: 24 each tank (12 for the grit section, 12 for the grease section)
- Sealing of the odors: angular profiles 80 x 80 x 2,5 mm – plate 150 mm
- Gasket: EPDM minimum thickness 5 mm
- Central sealing of the odors: nylon brushes width 120 mm mounted on an aluminum frame fixed at the covers.
- Central run of the bridge scraper support for grease and grit sections: maximum 220 mm.
- Fasteners: dowels 6 x 60 mm A 4 – dowels 12 x 140 mm A 4 - Screws 4,8 x 25 mm A 4
- N. 6 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.4 Primary Sedimentation Tanks Covers

Design and supply of Aluminum Flat Covers for the n. 2 rectangular Primary sedimentation tanks each one with n. 6 lines with sizes 7,5 x 32 mt. for a total cover surface of 2.880 sqm.

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 7,7 mt.
- Flat panel width: 695 mm
- Flat panels height: 180 mm
- Flat panels weight: 67 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls min. 10 cm each side
- Sealing of the odors: angular profiles inferior 160 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 24 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.5 Technical Description Primary Sludge Thickeners Covers

Design and supply of Aluminum Flat Covers for the n. 3 Primary Sludge Gravity Thickeners with diameter 18 mt. for a total cover surface of 764 sqm.

- Type of covers: Aluminum flat panels

- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 8 mt.
- Flat panel width: 695 mm
- Flat panels height: 180 mm
- Flat panels weight: 67 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls, on the angular profiles min. 10 cm each side
- Angular profiles: L aluminum 5754 H 32 thickness 5 mm fixed at the central concrete walls of the existing beam.
- Sealing of the odors: angular profiles inferior 160 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 4 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.6 Buffer Tanks 1 Covers

Design and supply of Aluminum Flat Covers for the n. 2 Buffer Tank 1 with diameter 8 mt. for a total surface of approx. 100 sqm.

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 8,2 mt.
- Flat panel width: 695 mm
- Flat panels height: 180 mm
- Flat panels weight: 69 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls min. 10 cm each side
- Sealing of the odors: angular profiles inferior 160 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 2 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.7 Buffer Tanks 2 Covers

Design and supply of Aluminum Flat Covers for the No. 1 Buffer Tanks 2 with diameter 22 mt. for a total surface of approx. 380 sqm.

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness

- Flat panels unitary length: 5,5 mt.
- Flat panel width: 815 mm
- Flat panels height: 120 mm
- Flat panels weight: 49 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls min. 10 cm and on the 3 beams lines 8 cm minimum.
- N. 3 lines of internal beams CG 500/30 consisting in aluminum extruded beams in 6063 T 66 with total length of 55 mt.
- Beams height 500 mm – beams weight 30 kg/mt. Beams width 200 mm. The beams are completed of inferior L profiles in both sides for the loading of the panels minimum 8 cm.
- N. 3 stainless steel A 4 columns diameter 219 mm thickness 5 mm complete of inferior plate 10 mm thickness for fixing in the tank and superior plate 10 mm thickness for fixing of the aluminum beams.
- Fixing beams on the concrete external walls: Stainless- steel A 4 Bars 12 x 250 mm + chemical resin
- Fixing beams on the stainless- steel columns: A 4 bolts M 12 x 50 mm
- Sealing of the odors: angular profiles inferior 120 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 4 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.8 Buffer Tanks 3 Covers

Design and supply of Aluminum Flat Covers for the No. 2 Buffer Tanks 3 with diameter 35 mt. for a total surface of approx. 1924 sqm.

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 5,7 mt.
- Flat panel width: 815 mm
- Flat panels height: 120 mm
- Flat panels weight: 52 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls min. 10 cm and on the 3 beams lines 8 cm minimum.
- N. 5 lines of internal beams CG 500/30 consisting in aluminum extruded beams in 6063 T 66 with total length of 175 mt.
- Beams height 500 mm – beams weight 30 kg/mt. Beams width 200 mm. The beams are completed of inferior L profiles in both sides for the loading of the panels minimum 8 cm.

- N. 8 stainless steel A 4 columns diameter 219 mm thickness 5 mm complete of inferior plate 10 mm thickness for fixing in the tank and superior plate 10 mm thickness for fixing of the aluminum beams.
- Fixing beams on the concrete external walls: Stainless- steel A 4 Bars 12 x 250 mm + chemical resin
- Fixing beams on the stainless- steel columns: A 4 bolts M 12 x 50 mm
- Sealing of the odors: angular profiles inferior 120 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 10 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

B.3.2.8.9 Dewatered Sludge Silo Covers

Design and supply of Aluminum Flat Covers for the No. 4 Rectangular Dewater Sludge Silo, with sizes 4 x (7.5 x 10m) for a total surface of approx. 300 sqm.

- Type of covers: Aluminum flat panels
- Material: Aluminum alloy 5754 H 32 – minimum thickness 2,5 mm
- Stiffeners: angular profiles welded 60 x 60 x 2,5 mm thickness
- Flat panels unitary length: 6 mt.
- Flat panel width: 815 mm
- Flat panels height: 120 mm
- Flat panels weight: 54 kg each
- Flat panels shape: male / female interlocked
- Flat panels loaded on the external concrete walls min. 10 cm each side and on a diametral Aluminum beam
- N. 1 diametral beam height 500 mm – beam weight 30 kg/mt. Beam width 200 mm. The beam is completed of inferior L profiles in both sides for the loading of the panels minimum 8 cm.
- Sealing of the odors: angular profiles inferior 160 x 80 x 2,5 mm, superior 80 x 80 x 2,5 mm.
- Gasket: EPDM minimum thickness 5 mm
- Fasteners: dowels 6 x 60 mm A 4 – Screws 4,8 x 25 mm A 4
- N. 4 Aluminum single door manholes 600 x 600 mm with hinges and handless in stainless steel

Mandatory certifications for the Aluminum structures and covers supplier:

- CE 1090/3 for Aluminum Structures
- ISO 9001
- ISO 14000
- Certificate of the Chamber of Commerce to confirm the company activity and experience in Aluminum structures and covers
- To have produced in the last 3 years Aluminum covers and beams installed on Waste Water Treatment Plants for at least the same amount of the scope of supply of this project

B.3.2.9 Discharge Pumping Station

The pumping station is under good condition. It needs finishing works. The pumps are in acceptable operating conditions. They can be used with proper maintenance and refurbishment. They are operated manually.

The following works are recommended for the pumps, to be implemented in Phase 1:

- Overhaul of the existing pumps and supply/install new pump with same capacity to be fitted in the space already allocated for that purpose
- Overhaul of the existing piping and valves
- Replace the instruments by new ones to include: Float switches, hydrostatic level sensor, high/low pressure switches.
- Maintain the existing electromagnetic flowmeter on the DN1200 discharge main
- Update the operation and control of the pumps so that variable speed can be operated automatically and the full protection of the pumps will be functional

It is to mention that the existing DN1200 sea outfall is designed to receive a peak flow of 2.6 m^3/s. The ultimate flow that it can receive is 3.6 m^3/s. It was initially designed that flows exceeding those values will be diverted to the gravity sea outfall. In the current design for phase 1, both sea outfall will be used simultaneously during the ultimate peak flow of 5.13 m^3/s.

B.3.3 Storage of Consumables

Storage facilities representing at least 21 days' autonomous operation must be provided for all consumables (reagents, fuels, etc.) that need to be delivered, calculated on the basis of the maximum consumption of the product concerned. Delivery, unloading and storage points must be provided within the units where these products are consumed and in such a way as to facilitate operation with healthy situation.

B.3.4 Measurements – Regulation – Supervision – Remote Control – Remote Surveillance

The installation contains all the measuring devices required to ensure correct operation from the general control room, together with the monitoring, regulation and automation devices ensuring reliable operation and the safety of both staff and installations. Measuring devices shall transfer data automatically in electronic format to the central supervision computer.

Slaving systems must always be fitted with by-passes (in the event of a break-down or for maintenance) to allow manual or semi-automatic operation (operation during specific periods or on a rate-duration basis, for example).

B.3.4.1 Measurement Devices

Depending on the processes used, the Contractor shall propose the measurements that he feels provide the necessary information for correct operation of the installation.

The devices that are necessary or required by regulations must be provided at the proper places.

Generally speaking, the measurement technique shall comply with international standards and be approved in the case of those required by regulations. Any devices not covered by standards must be of recognized design, suited to the situation in question and approved by the Engineer.

Measurement points shall be placed at the best places for observing the phenomena or physical values to be measured.

The installation also includes the offtakes or devices needed for carrying out tests, checking performance levels, making assessments, etc. in sufficient numbers to provide a complete understanding of each function.

The devices shall be installed in such a way that they do not affect the measurement in question through turbulence, blockage, thermal bridge effect or hydrostatic loading.

Instantaneous values and measurements shall be electronically transferred to and recorded into the central supervision computer in the control room.

All measuring devices must be sized for the final capacity of the plant.

All measuring devices must be installed in fixed positions and connected to the computerized supervision center.

The installation shall include at least the following components (list not exhaustive):

1. Water flowmeters:
   - At the plant inlet.
   - At the plant outlet.
   - Grit and grease removal outlet grease.
   - Waste water tank outlet.
   - Drainage water tank outlet.
   - Deodorization circulation pumps outlets.

In all cases, the flow shall be metered by a device that will remain accurate and reliable for the range of 10% to 110% of the nominal discharge.

Measurements must be accurate to within ±1.5% over the theoretical discharge measurement range.

2. Air flowmeters:
   - Grit removal system air blowers outlet.
   - Air process blower outlet (buffer tanks, gas transfer, etc.).
   - Air flow for deodorization ventilator outlets.
3. Level meters:
   - In all storage and reagents tanks and pump pits. The main pumping stations shall have dual level control system: duty one consisting of ultrasonic or hydrostatic instruments, standby one consisting of float switches

Each measurement can be read locally and shall be transferred to the control room.

Ultrasonic metering is preferred.

4. pH-meter:
   - At the plant intake.
   - At the outlet of the plant.
5. Temperature:
   - At the plant inlet.
6. CH_4 measurement:
   - In the air in the sludge building.
   - In the air in the deodorization area.
7. H_2S measurement:
   - In the air in the pre-treatment area.

- In the air in the Primary Settling area.
- In the air in the Biofilter area.
- In the air in the Sludge treatment area.
- In the air in the Odor treatment area.

8. Reagent flowmeters:

All reagent circuits must be fitted with flowmeters downstream of the dosing pumps.

Flowmeters shall be of the rotameter type for readings to be taken locally.

9. Electricity:

All equipment shall be provided with a meter giving readings of total operating times.

The electricity consumed by the entire treatment plant must be broken down to show the following consumption levels separately:

- General items, notably:
  - The lighting system.
  - The HVAC system.
- Consumption of systems linked to the process:
  - Pre-treatment.
  - Biological Grease Treatment.
  - Primary Settling.
  - Biofilters.
  - Backwashing.
  - Sludge treatment.
  - Odor treatment.

B.3.4.2 Regulation Devices – Automatic Controllers

The electromechanical equipment of each sub-assembly of the plant shall be controlled by local regulation devices and automatic controllers on a hard-wired or programmable logic basis.

These automatic controllers must comply with the following specifications and limiting factors:

- Integrated lightning arresters.
- Autonomous operation (by means of a rectifier-battery-UPS assembly) in the event of a power cut.
- Any automatic controller must be fitted with a by-pass system so that the corresponding unit can be switched to manual or semi-automatic mode.
- Link with the central control room for transmission of all information and for remote control from the central room.

The regulation principles shall be as follows:

- Screen cleaning: Detection of head loss or controlled by time.
- Great and Grease removal: Controlled by time or by incoming flow rate.
- Aeration: Measurement of dissolved oxygen and controlled by time.
- Centrifuge: Controlled by time and level in the sludge tank.

- Polymer injector: Controlled by the flow.
- Odor treatment ventilators: High speed controlled by H2S & CH4 measurements.
- Outlet Pumping Station Power Supply failed: Command the stop of the Pumping Stations upstream the Wastewater Treatment Plant.

In case of failure of the outlet pumping station, and in order to prevent any direct discharge on the sensitive maritime area downstream Expansion and Upgrade of Al-Ghadir WWTP Project, a remote command to stop the pumping station upstream will be sent. The overflow of such pumping station will consequently apply.

B.3.4.3 Supervision and Assistance with Maintenance

The Contractor's services include the supply and installation of the hardware and software needed to implement a supervision and maintenance program, as defined below.

Information concerning the operation of all the equipment and measurement signals from the measuring devices shall be transmitted to a central unit situated in the control room, providing, Supervisory Control and Data Acquisition (SCADA).

In the event of a power cut, this system can work autonomously via a rectifier-battery-UPS assembly. The PLC shall have Lithium batteries and autonomy of 4 hours. It can be interrogated remotely via the telephone network.

The SCADA system is responsible for at least the following functions:

- Assistance with operation:
  - Displaying and printing out of alarms (machine faults or measurement/time value thresholds exceeded).
  - Color mimic display (23" minimum size) possibly broken down into sub-displays showing the various parameters affecting each structure, item of equipment or sensor.
  - Downloading of various types of information: presence of staff, electricity consumption, etc.
  - Exploitation of measurements: averages, graphs.
- Assistance with maintenance:

The system is used to update files on all existing and future structures and equipment and on suppliers and to draw up a program of preventive maintenance.

- Printing of records:

Records of the main data over the period required.

- Filling:

Automatic filling on a suitable medium of information forming the journals, after a period to be defined.

B.3.4.4 Remote Control

The SCADA system provides remote control of all essential equipment in the installation to the control room.

The SCADA system provides remote command of all essential equipment in the installation from the control room.

Hot Redundant PLC’s will be installed in the control/command panel in the electrical room of the sub-station.

Deported Input/output modules (RTU) will be installed in the control/command panel in the electrical room of the building corresponding of the principal phases of the process.

The connections between the control room, the PLCs and the deported I/O modules shall be realized by an optical fiber ring.

The arrangements made by the Contractor are to be set out in detail in his design.

B.3.4.5 Remote Monitoring

It must be possible to alert any duty staff either manually and automatically by telephone of any malfunctions in the plant.

The Contractor shall describe the system he intends to set up in this respect.

It must also be possible to interrogate the system remotely via an intranet or the Internet.

B.3.4.6 Control Room (Scada Center)

The SCADA system shall be installed in a control room.

The SCADA system shall be composed of a minimum of:

- One Engineer workstation (Administrator).
- Two Operator workstations.
- One Maintenance workstation.
- Two redundant servers.

B.3.5 Electricity Supply

In addition to the existing transformers and generators building, two new power supply buildings shall be constructed including transformer substations and generators; one building in the existing WWTP site and another one in the new WWTP site.

The total capacity of the new electrical installation must be suited to the requirements defined by the Contractor plus a 25% allowance for further equipment.

The indoor-type substation shall comprise the following main items:

- Incoming cells.
- Switchboard bus section cells.
- Busbar metering cell.
- Transformer feeder cells.
- Oil power transformers.
- MV cables and MV cable terminations.
- LV cables and connections.
- Main Distribution Board (MDB).
- Power Factor compensation panel.
- Motor control/command cubicles.
- Automatic changeover switches.
- Variable Frequency Drives.
- Signaling relays and indicator lamps.
- Select mode switches (Automatic/Manual/Stop).
- Select mode switches (Run/Stop, Open/Close, etc.)

- LV circuits-breakers and tripping systems.
- LV contactors and relays.
- Lightning arrester.
- Earthing.
- Monitoring and safety accessories.

The Contractor shall also be responsible for the following:

- Costs and procedures for obtaining the agreement of the energy distributor. The services shall comply with the rules for constructing and installing subscriber substations issued by Lebanon Electricity Authority.

The power supply network being unreliable, a prime generator and a stand-by generator shall be installed so as to ensure the whole plant energy supply during the recurrent power cuts.

The prime generator shall be started automatically and immediately in the event of a power cut (Electrical network). The stand-by generator shall be started automatically and immediately in the event of a failure on the prime generator.

The generators shall be powered by a fuel tank ensuring 7 days autonomy on the basis of 8h/day operation of the generators.

Lightning system shall be installed.

The electrical power distribution shall be made through Motor Control Center (MCC) installed in the electrical room of the following buildings:

- Lift Station.
- Bar Screens.
- Degritting Area.
- Pumping Station.
- Blower Room.
- Primary Treatment
- Odor Treatment.
- Sludge Dewatering.
- Gravity Thickening Pumping Station.
- Mechanical Thickening Secondary.
- Anaerobic Digestion.
- Digester Sludge Buffer Tank.

Each Motor Control Center (MCC) shall comprise the following main items:

- LV cables and connections.
- Motor Control Center panel.
- LV circuits-breakers and tripping systems.
- LV contactors and relays.
- Variable Frequency Drives.
- Motor Soft Starters.

- Signaling relays and indicator lamps.
- Select mode switches (Automatic/Manual/Stop).
- Select mode switches (Run/Stop, Open/Close, etc.)
- Lightning arrester.
- Earthing.
- Monitoring.

In each building, a Sub-Panel Board (SPB) must be installed to supply the utility equipment.

Each Sub-Panel Board (SPB) shall comprise the following main items:

- LV cables and connections.
- Sub-Panel Board panel.
- LV circuits-breakers and tripping systems.
- LV contactors and relays (If required).
- Signaling relays and indicator lamps (If required).
- Lightning arrester.
- Earthing.
- Monitoring.

B.3.6 Networks - Utilities

B.3.6.1 Networks

All networks shall be designed for the nominal/peak or surge capacity; they include the following systems:

- Connections between structures

  All hydraulic connections required for the proper operation of the installation are to be provided by the Contractor, along with all inspection holes on pipes.

  By-passes with easy access are to be provided for each treatment structure.

  High quality valves with easy access shall be provided to cut off each treatment structure and each section of by-pass pipe individually.

- Service industrial water network

  This is fed with treated water taken from the treated water tank and pressurized to service pressure. The necessary discharge shall be determined by the Contractor in accordance with his design.

  The network serves all the sections of the plant with pressurized water and shall be regularly monitored for water quality Each place shall be fitted with at least one tap. The available head at the taps shall be 4 bars. Additionally, pressure regulation and safety valves should be considered for sensitive equipment that may require stable, lower pressures

  A 50 ND water offtake shall be provided close to each treatment structure.

- Internal sewerage network

  An internal sewerage network shall collect all the internal sewerage water such as draining water from all process, residual chemical water from all process, sanitary sewage, raining water collected on the path of wastes and reagents loaded trucks, … The selected material should resist corrosion and chemical degradation, with the use of liners where necessary.

This network shall be sized according to due justifications plus a 10% allowance; in these calculations, the rainfall with 10-year return period shall be used for inflow on the concerned areas, in addition to the peak of the firefighting needs.

This network shall convey water to a pit, to be designed by the contractor with adequate volume, fitted with pumps; whatever the number of pumps, 1 stand-by pump shall be available on-the-spot and shall starts up automatically, with a robust and regularly tested automatic start-up mechanism, if another pump breaks down; this pump shall have exactly the same characteristics than the other ones. A circular working could be established among the pumps in order to use all of them in a similar manner. Automated monitoring and control systems (flow meters, pump indicators, alarm systems for pump failure…) shall be integrated to ensure efficient operation and prompt detection of issues.

These pumps shall deliver flow upstream the secondary treatment and they shall be maintained on a regular basis.

- Fire-fighting network

This network shall be supplied by the service industrial water network in accordance with the regulations in force. Regular maintenance and testing of the system will be essential to ensure its effectiveness during emergencies.

B.3.6.2 Lighting

The specified intensity for led lighting with motion sensors shall be, unless otherwise required, as follows:

- Outside ways: ≥ 20 luxes.
- Inside ways and stairs: ≥ 100 luxes.
- Room inside buildings: 300 luxes.
- Offices inside buildings: 500 luxes.

These installations shall be delivered in working order, including the network, inspection holes and protection panels, using durable and suitable material for the specific environment.

B.3.7 Pipes

B.3.7.1 Pipes Design Works

The process wastewater and sludge pipes design works can be summarized as follows:

B.3.7.1.1 Phase 1 (Design and Execution in Current Tender. For More Details refer To Tender Drawings)

A- Inside Existing WWTP Site:

- Pipes having diameters ranging from DN 800 to DN 1800 shall connect the existing preliminary treatment (Aerated degritting tanks) to the primary sedimentation tanks, then from the primary sedimentation tanks currently to the existing sea outfall system and, in the future, to the secondary treatment. These pipes will have a total length of approximately 0.5 km.

B- Connection Between Existing and New Al-Ghadir WWTP Sites:

- Two DN 250 sludge pumping pipes shall be used to transport the primary sludge through pumps nearby primary sedimentation tanks to the sludge treatment area (Primary Sludge Thickener), having a total length of around 1.05km)
- 1 DN 250 sludge transmission pipe shall carry dewatered sludge supernatant to the inlet works, with a total length of around 0.4 km.

C- Inside Reclaimed Land of New WWTP Site - Sludge Treatment Area - Phase 1:

The pipes shown in the technical drawings and schematics, connecting the structures within the reclaimed land (Primary sludge treatment area - Phase 1), shall be designed by the contractor and submitted for the Engineer's approval.

B.3.7.1.2 Phase 2 (Only Design in the Current Tender)

A- Connection Between Existing and New Al-Ghadir WWTP Sites:

- Two DN 1400 pumping pipes will be used to transport primary effluent from the interim lifting station wet well at the existing WWTTP site to the distribution unit/box of the biological treatment basins, located in the reclaimed area, having total length of around 1.7 km
- Two DN 1400 transmission pipes will be used to transport the TSE from the secondary treatment (chlorine contact) in the reclaimed land to the existing sea outfall systems (existing Mh-E2 and main pumping station) at the current WWTTP site, with a total length of around 2.6 km and a peak flow rate of 5.13m^3/s)

B- Inside Reclaimed Land of New WWTP Site:

The pipes shown in the technical drawings and schematics, connecting the structures inside the reclaimed land (Secondary biological and sludge treatment), shall be designed by the contractor and submitted for the Engineer's approval.

B.3.7.2 Pipes, Fittings and Manholes - Design Criteria

Unless otherwise specified and considering the proximity of the WWTTP sites to the sea, the selection of materials for pipes shall respect the following general rules:

- Gravity / Pressurized inlet pipe for waste water, as well as internal and main connection sewage and sludge pipes:
  - Spiral welded steel pipes for diameters greater than 800mm (Produced According to EN 10217-1 / Steel Grade S235JR to EN10025-2 with an External HDPE Coating to DIN 30670 3mm thick and an Internal Solvent Free Epoxy lining to AWWA C210 400 microns thick). Beveled Ends with a Standard Pipe Length 13.5m.
  - Standard / restrained ductile iron will be used for pipes diameters up to 800mm, with an appropriate protective coating or lining (such as high alumina cement mortar, epoxy, bituminous…) corrosion inhibitors, cathodic protection, etc…, for exposure to salty environments or other severe conditions, and/or as specified by the manufacturer.
- Gravity / Pressurized pipe for industrial service water, chemical networks (reagents) and fire protection: HDPE (High-Density Polyethylene), with a UV-resistant coating for above-ground installations in coastal areas to protect against sunlight, or with additional protective layers for outdoor buried installations to safeguard against saltwater and/or as specified by the manufacturer.
- Gravity pipe for clarified water (Ductile Iron as per sewage network recommendations) or raining/draining water: Reinforced concrete (Water canal with heavy duty grating as shown on tender drawings / pipe Class III-wall according to ASTM C76 and AASHTO M 170), with an appropriate internal protective coating (epoxy…) or lining (HDPE liner…) to prevent corrosion on the interior side of the concrete pipes, and an external surface coating to protect the pipe against the external environmental conditions and/or as specified by the manufacturer.
- Pressured pipe for compressed air: 316L stainless steel, with an appropriate coating or additional layer of protection (such as polymer or an epoxy-based coating…) and/or as specified by the manufacturer to enhance its resistance to the harsh conditions, (abrasion, UV protection, chemical resistance…) especially if the pipe is exposed to the elements.

On the route of the gravity pipes, manholes with proper seals shall be installed each 100m or at each bending point; to provide easy access for inspection, cleaning and maintenance of the pipes.

Miscellaneous Criteria for Pipes and Manholes:

- All pipes shall be fitted with underground pipe markers or detectable warning tape, located 50cm above the pipe's crown level.
- Minimum pipe cover 0.8m.
- Thrust blocks and pipe anchorages shall be constructed on all pressure mains at each change of direction and wherever a toe junction or blank end is constructed. Thrust Blocks shall be constructed of Class "B" concrete. In confined areas, restrained joints may be used to eliminate the need for thrust blocks.
- Unless otherwise shown on the Drawings, all iron pipes passing through concrete walls or other similar structures shall incorporate a puddle flange. Such flanges shall be of the same dimensions as flanges for the size and class of pipe to which they are attached, and the cost thereof shall be included by the Contractor in the appropriate items of the Bills of Quantities.
- Pipes and manholes shall undergo the following tests, alongside visual inspection:
    1. Vacuum Test for manholes
    2. Low-Pressure Air Test, Exfiltration and Infiltration Test for gravity sewer piping
    3. Hydrostatic Testing for pressure piping
    4. Deflection Testing for plastic pipe.

B.3.7.3 Pipelines and Fittings Applicable Standards

ISO, EN, BS, NF, AFNOR, ASTM, AWWA standards

B.3.8 Civil Works

B.3.8.1 Scope of Section

This clause contains the design requirements for the new structural design and rehabilitation/upgrade of treatment units, buildings, retaining walls/abutment walls, bridge crossing, manholes, channels, culverts, etc., to be adopted by the Contractor in his design. Concerning choice of materials, structures shall generally be constructed of reinforced concrete.

B.3.8.2 General

All structures shall comply with the Lebanese construction regulations and laws.

The buildings shall be aesthetically attractive using high quality materials and workmanship.

All buildings shall be designed as reinforced concrete frame structures with local hollow brick – plastered walls. Structural steel or wood may be used for the support of the roof.

Steel structures shall be uncoupled to any vibrating equipment.

The structures shall be designed using internationally recognized building design software. All output shall be neatly presented in English language.

Concrete used for the underground and hydraulic structures shall be watertight. The Contractor shall issue a concrete mix design for the Engineer's approval prior to any concrete works.

All concrete of hydraulic structures shall be made of Sulphate Resistant Cement, and it is to be noted by the Contractor that the concrete will be exposed to very sever conditions (concrete surfaces occasionally exposed to sea-water spray) according to BS5328

B.3.8.3 Clarifications

In case of discrepancies, absence, annulment or justified departure, in particular due to technical progress, the Contractor clarifications/propositions shall be submitted to the Engineer explanations/acceptance.

B.3.8.4 Types of Structures

For design purposes reinforced concrete structures shall be classified as follows:

Type 1 – Reinforced concrete structures which are not normally subject to hydrostatic pressure and are not liquid retaining. Type 1 structures shall be designed in accordance with BS EN 1992-1-1:2023 or equivalent.

Type 2 – Reinforced concrete structures which are normally liquid retaining or periodically in contact with liquids. Type 2 structures shall be designed in accordance with BS EN 1992-1-1:2023 as well as BS EN 1992-3 or equivalent.

If for some specific structures, prestressed/posttensioned concrete is proposed to be used, it shall be in compliance with the above-mentioned standards for Types 1 or 2.

To be noted that the structural design shall cover all the constructions in both existing and new WWTP sites for Phase 1 and Phase 2, including the constructions to be rehabilitated and/or extended.

B.3.8.5 Load Conditions

Combination of design loadings shall be applied to find the maximum stresses, subject to practical considerations (including seismic). All type 2 structures shall be designed for both full and empty conditions with allowance made for any active or at rest soil pressures on walls. No relief shall be given for any passive soil pressure on a wall, on the face remote from a contained liquid.

All liquid retaining structures shall be designed to resist an internal liquid level to the maximum top working level such that the requirements of BS EN 1992-3 are not exceeded. In addition, liquid retaining structures shall be designed to resist a liquid level equal to the maximum possible top water level under Ultimate Limit State (ULS).

All reinforced concrete structures shall be designed to permit the external excavation to be backfilled prior to construction of the ground level slab and superstructure. In addition to the calculated external earth pressures, walls shall be designed for any surcharge (including construction traffic) which may be applicable and for the appropriate ground water pressures.

B.3.8.6 Foundation Design

Foundation design shall be performed for all the new constructions (Including structures extension) in the existing and new WWTP sites, and for both Phase 1 and Phase 2; however, the execution works will be limited to Phase 1, in both existing and new WWTP sites. The foundation design shall be based on the geological and geotechnical data derived from field investigations and subsequent laboratory testing for the site. All foundations shall be checked against allowable bearing capacity and settlement (total and differential), and designed against buoyancy (If any) and volume change potential of the underlying soil by changes in moisture content (site-saturation).

The Contractor shall prepare a geological/geotechnical report defining the soil parameters to be used in the design (including modulus of subgrade reaction, coefficient of consolidation and seismic, but not limited to) and proposing the method of excavation, ground treatment/improvement and stabilization, underground drainage, and foundation system. The Contractor may use the geological/geotechnical information given in the tender documents; however; the given information shall be validated by the Contractor through further geological/geotechnical investigations (as specified and/or as directed by the Engineer), at design or subsequent stages of the works, in order to fully ensure the adequacy of the designs with regard to the actual ground conditions.

The Contractor's foundation and structural design shall take account of the likelihood of settlement (Including long-term consolidation settlement, if any) and suitable measures such as foundation soil replacement, enlargement of foundations, deep foundations and etc. shall be adopted where necessary. Particular problem areas (If any) for foundation settlement include different foundation levels and loading within single structure and the interaction of foundation loads between adjacent structures, shall also be taken into consideration in structural design.

B.3.8.7 Structure Layouts

Layouts of structures shall incorporate suitable joints, complete with water bars where necessary, to accommodate shrinkage, thermal and foundation movements.

Links between structures such as walkways, channels and pipeline connections shall be suitably jointed to accommodate relative movement, both horizontal and vertical.

B.3.8.8 Earthquakes

The Contractor shall design structures according to local seismic rules and data, submitted to the approval of the Engineer. The Contractor shall carry out all additional investigations necessary, at design or subsequent stages of the works, in order to fully ensure the adequacy of the designs with regard to the area seismicity. The seismic design of reinforced concrete structures shall be according to UBC-1994.

B.3.8.9 Materials

All materials shall be compliant with Lebanese standards and the other specific standards mentioned in the tender documents and drawings.

All materials shall be chosen considering the aggressivity of liquids and exposure condition (According to BS5328) to present a resistance to corrosion in adequation with the service life of the structures.

B.3.8.10 Earthwork and Excavations

This work shall consist of clearing and grubbing, stripping, removal of unsuitable soil, excavation, fill and backfill, and other specified works related to the earthwork.

To be noted that the present stockpiles of backfill materials, located in the new WWTP site, shall be removed by third party (Landfill Contractor) prior to the current project execution.

Excavation shall be made in open cutting and shall be taken out as nearly as possible to exact dimensions and levels shown in tender drawings.

The Contractor shall ensure the stability and safety of excavations and shall take all measures (on his own expense) necessary to ensure that no collapse or subsidence occurs.

Excavations shall be kept free from water and it shall be the Contractor's responsibility to construct and maintain temporary diversion and drainage works and to carry out pumping and to take all measures (on his own expense) necessary to comply with this requirement.

The backfilling with engineering fills (0/406.4mm and/or 0/127mm, refer to tender drawings) shall uniformly be done around the structures (up to the elevation +4.5 that is the finishing ground level of the new WWTP site), chutes, culverts, manholes, retaining walls, or other structures.

The engineering fills shall be as noted in tender drawings. The engineering fills shall be compacted (>=95%) at optimum water content by using at least 12-ton-static class single-drum vibratory smooth roller.

In confined and semi-confined areas, compaction shall be done by using 4-stroke engine tamper having a basic weight at least 55Kg and 4 to 8-ton-static single-drum vibratory smooth roller, respectively.

The subgrade soil to a depth of 20cm shall also be compacted (>=95%) to a dense and stable course (at optimum water content) prior to start backfilling.

B.3.8.11 Deep Dynamic Compaction Works

Neither loose to medium dense Manmade Fill up to elevation +2 nor the multi-layered foundation soil (Manmade Fill and underlying Gravely very Silty medium dense to dense fine SAND) with water table (seawater) at bottom level of foundation, cannot be considered safe bearing strata for the Expansion and Upgrade of Al-Ghadir WWTP, accordingly; the multi-layered foundation soil shall be densified by Deep Dynamic Compaction (DDC) from the elevation +2 within the area and extent shown on drawings to a depth of 9.5m from the elevation +2. The DDC works are required in the new WWTP site, but only the works related to Phase 1 are necessary to be implemented in the current project, covering an area of about 20,400m^2.

The DDC is a process whereby a heavy tamper is repeatedly raised and dropped on a grid-pattern (6m by 6m) from a specified height to impact onto the ground surface, thereby transmitting high compaction energy into the soil mass. The tamper shall be raised and dropped by a single cable with a free spool hoisting drum (80% efficiency). The depth of improvement depends upon the tonnage of the weight, the height of the fall and the amount of energy applied per unit area. After each drop, craters created by the tamper shall be backfilled and graded with quarry runs Engineering Fill before the next drop is applied.

The DDC shall consist of high energy compaction by dropping octagonal heavy tampers, low energy compaction (called ironing phase) by dropping square light tampers, impact rolling by using impact roller with 3-sided non-circular steel drum, final leveling and smooth rolling. The DDC shall be designed and executed according to FHWA-SA-95-037, 1995.

A seismograph shall be used to measure the magnitude of ground vibrations being transmitted off-site. The Particle Velocity shall be limited to 19mm/sec during the DDC, accordingly; the DDC area shall be surrounded by a 3m deep and 0.6m wide trench as a ground-vibration barrier within a setback of 6m, to minimize the effect of ground-vibration and lateral soil-mass displacement on neighboring structures (such as the side-slopes of landfill cells and airport's runway).

An open trench is the most effective in reducing vibrations, however; open trench is a concern for side-slope stability of landfill cells and airport's runway. Accordingly, the open trench will be backfilled with loosely placed (dumped) compressible material resulted from excavation of the trench.

The verification tests (Pressiometer and Static Cone Penetration) shall be executed before and 30 days after the Deep Dynamic Compaction (including final leveling and smooth rolling), taking the multi-layered foundation soil improvement with additional time (due to dissipation of the excess porewater pressure) into consideration, to determine the depth and degree of improvement. The precored Pressiometer test in Manmade Fill shall be performed according to ASTM D4719. The Static Cone Penetration Test with Pore Pressure Measurement shall be performed according to ASTM D5778.

If the desired improvement (having dense to very dense Manmade Fill and underlying gravely very silty fine SAND that is called multi-layered foundation soil to a depth of 9.5m from the elevation +2) has not been achieved upon completion of Deep Dynamic Compaction; additional energy shall be applied, to result in greater ground improvement.

B.3.9 Roads, Landscaping and Fencing

B.3.9.1 Access Road, Internal Roads and Parking Facilities

The design and construction of a new access road connecting the existing WWTP to the new WWTP (Including the bridge crossing and abutment walls), new internal roads in both existing and new WWTP sites and the rehabilitation of the existing internal roads shall be part of this Contract, except the construction of the internal roads related to the Phase 2, located in the New WWTP site.

To be clarified that the design shall cover all the internal roads for both Phase 1 and Phase 2, even though the internal roads for Phase 2 will not be constructed, in the current project.

The access road shall have a surface-runoff-water drainage system; the drainage system shall consist of reinforced concrete water canal with heavy duty grating, precast concrete gutter and reinforced concrete pipe culvert with manhole and grouted rock riprap

The Contractor shall design and undertake works to ensure that the access road will not be flooded in the event of rainfall intensity for a return period of 100 years in the coastal area. The Contractor shall make all necessary hydrological and hydraulic studies to justify his design.

The surface-runoff-water drainage system of the internal roads shall be in line with overland-flow drainage system of the new WWTP site (Refer to Section 3.10).

In general, the new internal primary roads within the new and existing WWTP sites shall be not less than 6m wide. However, some secondary roads, where shown in drawings, shall be not less than 4m.

Asphalt surfacing shall be used for roads (including internal roads) and parking lots. Attention shall be paid to proper road engineering fill/subbase/base and surfacing thickness. The engineering fill, subbase/base courses and asphalt shall be as noted in tender drawings.

The rehabilitation of the existing roads shall include an asphalt reinstatement comprising repairing the substrata layers where needed (Base, subbase, …) and installation of a new asphalt layer (Minimum 6cm tick).

Three (3) covered parking facilities shall be designed using reinforced concrete and/or steel structures to accommodate a total of 12 passenger cars. Three new parking facilities shall be implemented in the new WWTP site, while the existing parking one, located in the existing WWTP, needs to be rehabilitated. All these parking spaces for cars shall be covered with polycarbonate sheets to provide sun/rain protection during the summer/rainy months.

In addition, uncovered parking facilities shall be provided beside the entrance of the existing WWTP site, replacing the old consultant building to be demolished

The Contractor shall submit a functional circulation drawing for heavy vehicles (AASHTO H-20 Truck), with a turning area for delivery of reagents and evacuation of sludge.

The design shall be in accordance with the following codes and manuals (but not limited to) available at the public works department of Lebanon:

- Standard Specification for Construction of Roads and Bridges – FHWA
- Reinforced and prestressed concrete bridges – BS EN 1992-2
- A Policy on Geometric Design of Highways and Streets – AASHTO

Latest editions of the above publications shall be used.

B.3.9.2 Landscaping

Grading with 15cm thick ground-covering-gravel (Size Number 3 according to ASTM C33) shall be used, to drain the overland-flow into reinforced concrete water canals (with heavy duty grating) located along with middle of the internal roads (main and secondary).

The completed treatment plant site shall have a good green look and shall be planted. Local durable tree and plant species shall be used. Evergreen and deciduous trees and plants shall be used to provide a year-around green look.

Concerning the landscaping of the existing WWTP site, the Bidder/Contractor shall also refer to the related proposed rehabilitation works as described in Section 3.14.3.

Automated irrigation system shall be provided using the treated water produced by the plant.

B.3.9.3 Fencing

Two meters high security fence made of vinyl coated galvanized chain link complete with barbed wire on the top of galvanized posts shall be provided around the entire new WWTP site. The posts shall be fixed to reinforced concrete continuous-footing by steel plates and bolts.

The main access gate shall consist of a 6 m wide, 2 m high, double-leaf door, made of vinyl coated galvanized mesh, to match the fencing. The mesh shall be framed with galvanized and painted steel hollow-tube that will be connected to post with hinges. The gate must be electrically operated and commanded by handheld remote-control units.

B.3.10 Drainage

Reinforced concrete water canals with heavy duty grating shall be provided along with middle of the internal roads (main and secondary). The overland-flow and surface-runoff-water shall be drained into these canals by means of grading with 15cm thick ground-covering-gravel, and the canals shall finally be discharged into a drop-manhole, and the drop-manhole shall be discharged into sea (or any other discharge point) through a reinforced-concrete-pipe line (900mm in ID). The pipe trench shall be according to ASTM D 2321, CAN/CSA B182.11, AASHTO - Section 30.

The Contractor shall design all the drainage system for Phase 1 and Phase 2 in the new WWTP site to ensure that the facilities/new WWTP/internal roads (main and secondary) will not be flooded in the event of rainfall intensity for a return period of 100 years in the coastal area. The Contractor shall make all necessary hydrological and hydraulic studies to justify his design.

The construction of the drainage works, located inside Phase 2 area, in the new WWTP are not covered in the current project.

However, the construction of all the drainage works that are needed to discharge Phase 1 area, in the new WWTP site, is an integral part of this project. These drainage works could be located inside or outside Phase 1 area and could allow the drainage of Phase 2 area, if required in accordance with the drainage design system.

B.3.11 Buildings

B.3.11.1 General

Buildings shall be of reinforced concrete structural frames with local hollow brick – plastered walls.

Pitched roofs shall be tiled and shall have suspended insulated ceilings.

Flat roofs shall be insulated and protected from thermal gain by a minimum of 70 mm thickness of insulating material, well fixed and protected, providing, heat reflective finish and allowing pedestrian access. They shall also have a minimum of 12 mm thick waterproofing membrane approved by the Engineer. The flat roof structure shall be complete with upstands and gutters so as to be completely waterproof and ensuring adequate roof drainage.

Floors and wall shall be isolated from rising damp with damp proof membranes and courses.

B.3.11.2 Fire Resistance

The covered areas shall meet the minimum fire stability requirements for at least two hours.

B.3.11.3 Structural Steel

Use of structural steel is allowed for the roof support structure.

B.3.11.3.1 Protection of Structural Steel Members

All structural steel members shall be hot-dip galvanized and painted. Manufacturing of steel members shall be in accordance with EN ISO 14713. Galvanization shall be in accordance with EN ISO 1461. The Contractor shall provide a certificate stating that the galvanization was done as per the above code.

Before painting, the steel members shall be checked for degradation of coating by blistering, peeling, flaking, cracking, lack of adhesion, etc. in the galvanizing. In case such a defect is found, the defected area shall be painted with zinc phosphate.

Finish of the steel members shall be done with polyester based resin with heat hardened powder. Finish color shall be selected by the Engineer from the RAL catalogue. Finish paint thickness shall be 60 to 80 µ and the adherence category class 0.

Protection and painting of steel members shall carry a five-year guarantee.

Care must be taken during transportation so as not to damage the steel members.

B.3.11.4 Miscellaneous Metal Items

Non-structural metal elements, such as handrails, stairs, ladders, fittings, etc. shall be made of stainless steel, aluminum or glass fiber reinforced polyester (GRP).

B.3.11.5 Structural Woodwork and Carpentry

Use of structural woodwork is allowed for the roof structure and visitor gangways.

Treatment of wood shall be in accordance with EN 335-1, Class 4.

All fittings, cables, brackets, etc. used in connection with woodwork shall be made of stainless steel.

B.3.11.6 Roofing

Building roof system shall consist of durable exterior surface, such as roof tiles or metal sheeting, waterproofing membrane, appropriate insulation, and interior surfacing.

Adequate roof drainage shall be provided by furnishing durable, corrosion protected rainwater gutters and piping.

B.3.11.6.1 False Ceilings

The administrative areas shall have false ceiling. The material used shall meet at least the following minimum requirements:

Dimensions: 60 x 60 cm

Fire resistance: Class M0

Humidity resistance: 100%

Coefficient of absorption W > 0.75

Fixing of panels shall be made with T profiles.

B.3.11.7 Windows/Ventilation Screens

B.3.11.7.1 General

Window frames shall be made of aluminum with minimum thickness of 20 microns. The Engineer shall select the finish color from the RAL catalogue.

The windows shall be equipped with secure locking mechanism and handles made of corrosion proof material.

Ventilation grilles shall be made of aluminum and shall be equipped with insect screens. Finish paint shall be thermal lacquer and the color shall be selected by the Engineer from the RAL catalogue.

B.3.11.7.2 General Glazing

The exterior windows shall meet the following requirements:

Thermal Coefficient U ≤ 1.7 W/m^2 K

Solar Factor as per EN 410 ≤ 0.63

The interior windows shall meet the following requirements:

Thermal Coefficient U ≤ 1.9 W/m^2 K

Acoustic factor Rw ≤ 33 dB

All external doors and windows shall be double glazed.

B.3.11.8 Doors

B.3.11.8.1 General

Doors into the treatment areas shall be waterproof and made of aluminum. They shall be made as sandwich construction with high quality, soundproof insulation.

Doors within the administration part of the building shall be made of wood.

All doors and door frames shall meet the fireproofing requirements as set forth for the building.

Electronically operated doors shall be provided where appropriate.

Doors into areas accessible by vehicles shall be made as sandwich construction of anticorrosion treated steel. Exterior and interior surfaces shall be coated with polyester lacquer.

Locks and handles shall be made of durable and corrosion proof material.

B.3.11.9 Security Systems

Security systems shall be provided at points of entry.

B.3.11.10 Stairs/Ladders/Handrails

Stairs shall be made of stainless-steel shade 316L.

Stairs, ladders and handrails shall comply with the Safety Regulations in force in Lebanon.

Ladders shall be made of anodized aluminum (class 20 minimum). Ladders shall extend 1.1 m above the level they lead.

Handrails shall be made of stainless-steel tubular sections, shade 316L or equivalent. They shall be designed to resist the anticipated impact loads. Top of the rail shall be 1.1 m from the finished floor level.

B.3.11.11 Flooring

All floor areas, except workshops and store rooms, shall be covered with ceramic tiles. Tiling used shall meet the following minimum requirements:

Size of tiles 20x20 or 30x30 cm,

Joint width 8 to 9 mm, Group B1

Surface durability EN 101 ≤ 8

Water absorption EN 99 ≤ 0.1%

Slip resistance ≥ R9

Expansion joints shall be provided at every 30 m^2. The joints shall be made of a combination of rigid and flexible PVC. Joint material shall be oil, acid, detergent, and fire resistant.

Skirting shall be provided for all tiled floors. Skirting height shall be 7 to 10 cm and the length of pieces shall match the width of the floor tiles.

Ant seismic movement joints in foundations and walls shall be composed of suitable aluminium profile coupled with a double strip flexible elastomer. Allowed movement shall be 4 to 6 cm.

Workshop and store room floor shall be covered with epoxy resin coating on top of concrete.

B.3.11.12 Wall Finishes

The below requirements are applicable for the new construction works as for existing constructions to be rehabilitated.

The external walls of the building shall be covered with 50 percent of local stone. The remaining external wall areas shall be rendered and receive a finish of colored aggregate in a resin base.

Internal finishes shall be as follows:

- Room ..... Acrylic emulsion
- Laboratory ..... Tiled from floor to ceiling
- Storeroom ..... Gloss paint
- Workshop ..... Gloss paint
- Kitchen ..... Tiling to 2.0 m, gloss paint above
- Dining room ..... Gloss paint
- Changing room ..... Tiling to 2.0 m, gloss paint above
- Toilets ..... Tiling to 2.0 m, gloss paint above
- Corridors ..... Gloss paint
- Stairs ..... Gloss paint
- Offices, meeting room, etc ..... Acrylic emulsion

B.3.11.13 Electrical Installations

B.3.11.13.1 General

Surface mounted galvanized steel conduits and fittings shall be provided in workshops. Elsewhere, wiring shall be installed in rigid PVC concealed conduits with flush fittings.

All electrical installations shall be approved by the Electricity Authority of Lebanon EDL).

B.3.11.13.2 Air-Conditioning And Ventilation

In general, the buildings shall have centralized systems for production of hot and chilled water and thermostatically controlled fan coil units in each room.

All offices and other rooms continuously occupied during working hours shall have variable speed ceiling fans at a suitable spacing.

However, Split Room Air Conditioners - Heat Pump could be provided for buildings air conditioning, having the adequate sizing and number for each room, based on the Engineer's approval.

The air-conditioning system of the administration and maintenance buildings shall be designed for the following conditions:

- Inside temperature ..... 21-23 °C
- Inside relative humidity ..... 40-60 %
- Outside summer temperature ..... 35 °C
- Outside winter temperature ..... 5 °C
- Outside summer relative humidity ..... 70 %
- Outside winter relative humidity ..... 65 %
- Ventilation rate ..... min 10 liters per person

The air-conditioning system shall be a central type, using Variable Refrigeration Volume, VRV heat pump systems with compressor motors controlled by an electronic inverter to meet any demand from 10% to 120% for cooling or heating. The outdoor condensing units shall have a copper fins. The system shall have a central exhaust and fresh air ventilation system.

The VRV system shall have individual fan coil unit controls as well as a central network remote controller.

EAC ripple control equipment shall be installed to the air-conditioning system as required by the local regulations.

They shall be suitable for operation in 45 ºC ambient temperature air cooled, horizontal air discharge type, comprising a compressor, condenser coil, condenser fan and motor, refrigerant receiver, charging valve and controls, assembled in a common casing. Unit to be tested at factory and supplied complete with refrigerant and dehydrated compressor oil. Unit to be of the heat pump type where required.

Appropriate ventilation system shall be provide ensuring the appropriate safe aeration, especially, for the technical rooms/areas. For some locations, a centralized ventilation system with all the needed ducting and motors could be needed, while in other locations separate fans could be adequate with the relevant air flow.

B.3.11.13.3 Computer Network and Telephone Cabling

Cabling shall be installed for all computers and telephones in the buildings to be connected to a data exchange network and main switchboard for the telephone system.

B.3.11.14 Cold Water System

A GRP tank of sufficient storage capacity for two days' full usage of mains water shall be installed as high as possible in the building, with a careful assessment of the building's structural integrity. The domestic water supply system shall comply with the British Code of Practice CP 310 or equivalent, and it shall be regularly monitored and maintained to ensure optimal performance while prioritizing health and safety considerations.

B.3.11.15 Hot Water System

The domestic hot water installation shall consist of:

- Locally made roof mounted solar radiation collector panels, insulated, copper type (Known for its high thermal conductivity and corrosion resistance), with regular maintenance of the panels.
- A pressure type cylinder with electric heating elements (To be sized to accommodate the peak demand).
- Forced circulation hot water distribution system, with regular maintenance of the circulation pump.

B.3.11.16 Signs and Notices

The Contractor shall provide appropriate project signs as instructed by the Engineer.

Notices to the utility companies as well as to the nearby industrial facilities whose daily operation maybe affected by the works under this Contract, i.e. roadwork inhibiting access, power cuts, etc., shall be given well in advance.

Directional signage shall also be provided to the completed building facilities.

B.3.12 Telecommunications

The administration building shall be provided with a switchboard and with telephone lines to all offices. One fax line and one broad-band internet connection shall be provided.

Telephone network infrastructure shall be installed, adequately embedded, including all needed civil works and ducting and cabling and related accessories.

B.3.13 Ancillary Buildings

B.3.13.1 Administration Building in Side New WWTP Site

The administration building to be constructed inside the NEW WWTP site shall have a minimum total area of about 200m^2 and must accommodate:

- A control room of about 50m², equipped with:
  - 6 floor units with suspended file supports and shelving,
  - main control desk with the following equipment: computers, printers, telephone,
  - 4 chairs on rollers, with arm rests, side table + 4 chairs,
  - 1 display panel (2 x 1 m),
  - 2 pedestal desks with additional angle units,
  - 2 side tables.
- Four offices, each about 20m² equipped with:
  - 2 floor units with suspended file supports and shelving,
  - 1 chair on rollers, with arm rests + 2 chairs,
  - 1 display panel (2 x 1 m),
  - 1 pedestal desk
  - 1 side table.
- A dining-room of about 50m², with:
  - sink and draining-board,
  - cupboard,
  - 2 heating plates.
- Toilets, with two WCs and washbasins for managers and visitors;
- A men's cloakroom with:
  - 4 showers,
  - 4 WCs and washbasins,
  - 20 lockers;
- A women's cloakroom with:
  - 2 showers,
  - 2 WCs and washbasins,
  - 5 lockers;
- Office automation equipment:
  - 4 PCs,
  - 1 black & white laser printer,
  - 1 photocopier,
  - 1 plotter,

- networking of the computer equipment (PC, printer, plotter).

B.3.13.2 Administration Building Inside Existing WWTP Site

A new administration building shall be constructed inside the EXISTING WWTP site, including a new laboratory and shall have a minimum total area of about 125m^2 and must accommodate:

- A Laboratory (Refer to Section 3.13.3)
- A control room, equipped with:
  - 6 floor units with suspended file supports and shelving,
  - main control desk with the following equipment: computers, printers, telephone,
  - 4 chairs on rollers, with arm rests, side table + 4 chairs,
  - 1 display panel (2 x 1 m),
  - 2 pedestal desks with additional angle units,
  - 2 side tables.
- Office room, equipped with:
  - 2 floor units with suspended file supports and shelving,
  - 1 chair on rollers, with arm rests + 2 chairs,
  - 1 display panel (2 x 1 m),
  - 1 pedestal desk
  - 1 side table.
- A kitchen, with:
  - sink and draining-board,
  - cupboard,
  - 2 heating plates.
- Toilets, with two WCs and washbasins for managers and visitors;
- Entrance

B.3.13.3 Laboratory

The existing main pumping station includes a laboratory that shall be rehabilitated through a separate project (UNICEF), covering the existing equipment.

Since the laboratory space is relatively small and the existing equipment is limited, Therefore, a new laboratory is proposed to be located inside the new Administration Building 1, in the existing WWTP and shall be fully equipped.

B.3.13.3.1 Design Requirements

This laboratory shall include at least two rooms, (i) one sample-receiving room (15 m²), (ii) one laboratory room (30 m²). The laboratory shall be implemented and equipped by the Contractor with water supply and drainage.

B.3.13.3.2 Specification for the Laboratory

The laboratory shall be equipped by the Contractor in order to perform the following analyses, in accordance with European Standards:

- pH,
- Conductivity,
- BOD,
- COD,
- TKN
- TP
- Dissolved oxygen,
- Suspended solids,
- Volatile matter,
- Settleable solids,
- Dry solids contents (in sludge)

3.13.3.2.1 Sample Receiving and Preparation Room

Small One room (about 15 m²) where the samples shall be received, registered, prepared (mixed, composited and where needed preserved) and stored. Sample bottles shall be cleansed and stored in this room.

This room shall have its own water supply and drainage and shall have two independent washbasins. It shall have two entrances one of which should be independent from the main laboratory in order to serve as a reception and another which should communicate with the main laboratory. This room shall be adjacent to the laboratory used by the Contractor.

The room shall be equipped with two refrigerators, a freezer, and a sonic homogenizer and shall have bench and cabinet area for storing required sample bottles, and chemicals for sample preservation.

An emergency shower and eye bath shall be installed.

3.13.3.2.2 Independent Laboratory Used by The Plant Operator

This laboratory shall be selected by the Contractor and validated by the Employer.

B.3.13.4 Accommodation Building

A new accommodation building shall be constructed in the new WWTP site and shall have a minimum total area of about 200m^2. The operators' accommodation building shall be designed to provide comfortable and convenient living quarters for the plant operators. This building must include as a minimum:

- Entrance: Approximately 10 m2
- Living Quarters:
- Four (4) Bedrooms each approximately 20 m^2 for accommodating 3 persons
- Four (4) bathrooms in addition to One (1) WC
- Common area for rest and relaxation, approximately 30 m^2.
- Kitchen Facilities: Equipped with appliances for cooking and dining, approximately 30 m^2.
- Recreational Room: Spaces for leisure activities to ensure operators can unwind during their downtime (Ping pong and/or others), approximately 30 m2.
- Safety and Security Features: Alarms, fire extinguishers, and other safety measures to ensure a secure environment.

These accommodations are essential for ensuring that operators can perform their duties effectively while maintaining a good work-life balance.

B.3.13.5 Workshop – Store Buildings

One new workshop and storage building is proposed to be constructed, in the existing WWTP site, while a main store building shall be constructed in the new WWTP site.

Each of these two building shall cover an area of about 200 m

The workshop and storage building shall be equipped with the following:

- a 2000 kg monorail with electrical lifting tackle,
- heavy-duty shelving (permissible unit loads of 100 kg), with storage compartments and trays (total length of shelving: 20 m),
- a fixed heavy-duty workbench with fixed parallel-jaw vice, 2.50 m,
- a wall panel for storing small tools, dimensions about 4 x 1 m,
- a set of tools: socket, flat and right-angled wrenches, screwdrivers, pliers, etc.,
- a compressed air pipe winder.

B.3.13.6 Chemicals Storage Building

The chemicals storage building shall be designed to safely store various chemicals used in the treatment process (mainly the sludge treatment chemicals). Here are some key features:

1. Containment: The building should have secondary containment systems to prevent leaks and spills from spreading. This includes spill containment berms or double-walled tanks.
2. Ventilation: Proper ventilation is crucial to prevent the buildup of harmful fumes and ensure a safe working environment.
3. Temperature Control: Some chemicals require specific temperature conditions to remain stable and effective. The storage area should be climate-controlled if necessary.
4. Labeling and Signage: Clear labeling and signage are essential for identifying chemicals and providing safety information.
5. Access Control: Restricted access to authorized personnel only helps prevent unauthorized handling and potential accidents.
6. Fire Safety: Fire-resistant materials and fire suppression systems should be in place to mitigate fire risks.
7. Compatibility: Chemicals should be stored according to compatibility guidelines to prevent reactions between incompatible substances
8. Capacity: The building shall be able to store all chemicals for one month usage autonomy.

B.3.13.7 Guard house

A new guard house shall be constructed in the new WWTP site, situated at the main entrance to the plant site, including: Reception, sitting room, bedroom, kitchen, toilet and washroom.

The guard house shall cover about 60m² and to be equipped with all the necessary furniture for each of the above-mentioned rooms, including: Bed, shelves, desks, tables, seats, chairs, …

To be noted that the existing WWTP incudes a guard house that shall be fully rehabilitated through a separate project (UNICEF) (Refer to Section 3.14)

B.3.14 Rehabilitation of Existing WWTP Constructions

B.3.14.1 Introduction

This section is intended to emphasize the needed rehabilitation works for the existing WWTP constructions, in line with the above requirements, incorporating a non-limited description of the proposed needed works. The rehabilitation of the existing WWTP constructions is a mandatory integral part of the "Expansion and Upgrade of Al-Ghadir WWTP Project – Phase I"

The rehabilitation/upgrading works concern the following existing constructions

Screw pumps lifting station, screw pumps motors and MCC building, Bar screens, Grit Classifiers, Aeration degritting tanks, Maing pumping station (Which includes operator room and Laboratory), Transformers and generators building guard house, Exterior structures and Landscape

The requested rehabilitation works are based on site assessment and take into consideration that some rehabilitation works are envisaged to be executed through separate project funded by UNICEF.

The detailed site assessment and proposed works description, in addition to the list of works planned to be executed in separate project are described in Part 5.

The mentioned below rehabilitation works consist mainly on the required civil works and the electro-mechanical and plumbing works (MEP) required for the building's usage in addition to the other exterior works in the existing WWTP site area, excluding the required process works that are addressed in the related mentioned above sections.

These works are presented in order to provide an approximate realistic primary data base that can guide the Tenderer/Contractor to estimate the works coverage and related cost amount. However, the works list and mentioned dimensions and quantities are indicatives and can be modified based on site evaluation or based on the above performance specifications requirements in order to ensure successful achievement of the tendered project implementation.

B.3.14.2 General Evaluation

The intended rehabilitation works can be summarized as follows:

- Extend some structures: Screw pumps lifting station, Screw pumps motors and MCC building, Aerated degritting tanks.
- Demolish existing constructions and construct new other structures at different locations: Blower room and fuel tanks.
- Demolish or adjust the existing concrete grit collection pits and replace the steel grit classifiers.
- Demolish damaged and not needed constructions: Old Consultant building and old WC rooms, located outside the fence.
- Rehabilitate the existing structures
- Revise the landscape finishing aspects.

Noting that some facilities will be under rehabilitation by UNICEF, namely: Access gate, fence, Guard house, laboratory, concrete repair and painting inside main pumping station building

In addition, the rehabilitation works, under execution by UNICEF, cover the metallic doors, windows, panel boards for all the buildings (Main pumping stations, Transformers and generators building, screw lifting station, and the blower room)

The works undertaken by UNICEF shall be checked if effectively they have been fully or partially implemented, during the execution of this project, in coordination with the Client.

If part or all of these works have not been executed, they could be added to the project works, based on appropriate cost submittal and the approval of the Engineer/Client.

B.3.14.3 Proposed Rehabilitation Works

The proposed rehabilitation works are presented here below specifically for each of the existing WWTP site structures.

To clarify that, the mentioned below works types, applicable also for the new constructions, shall include, but not limited to, the following works:

- Earth Works: Clearing and grubbing, grading, excavation, backfilling, all related needed materials according to the design requirements (Selected fill, engineering fill, draining fill, geotextile, …), ...
- Concrete Works: Providing and installing any type of concrete, steel reinforcement, Prestressed/post tensioned steel if any, hollow concrete blocks, waterproofing, damp proofing, sealant, all related needed materials…
- Finishing Works: All needed metallic and miscellaneous civil works: Plastering, painting, tiling, stone cladding, doors, windows, louvers, gratings, hand rails, aluminum covers, access covers, rails, false ceiling if any, structural steel, red clay tiles, roof drainage, ….
- MEP Works: Providing and installing all needed mechanical, electrical, plumbing works related to the structure functionality, excluding the works related to the waste water process (Accounted in other appropriate chapters). These works shall cover, but not limited to, the following:
  - Sanitary/Plumbing works: Sanitary fixtures, faucet and mixers, cold and hot water piping with fittings and accessories, electric water heater, water tank, booster, wastewater drainage system including piping with fittings and accessories, floor drains, floor washout, vents and roof vent caps, …
  - Earthing and lightning systems, final branch circuit panel board, lighting points, wiring devices, disconnector switches, luminaires with lamps, electrical and earth connections, wall and exterior mounted lighting fixture, Telephone socket outlet, doorbell, …

  To be noted that HVAC and firefighting systems works are: Exhaust fans, central system with ducting where needed, AC split units for heating and air conditioning

B.3.14.3.1 Screw Pumps Lifting Station

The screw pumps area covers the screw pumps basin, penstocks, inlet chambers, overflow chamber, …

As proposed in the current study, the screw pumps area shall be extended at both sides allowing the installation of 7 additional screw pumps alongside the existing seven, 3 at western side and 4 at eastern side.

The needed civil works can be summarized as follows:

- Demolish and cart away the overflow and inlet manholes located at the western side of the screw pumps basin
- Construct new inlet and overflow structure, and install all the needed pipelines connections and accessories, permitting the following:
  - Reconnect the existing stormwater pipeline (DN1500mm) to the inlet culvert, upstream the screw pumps lifting station structure.
  - Discharge the sewage overflow to the nearest existing overflow pipeline manhole.
- Construct new flow measurement structure/s upstream the screw pumps lifting station structure enabling to define the total influent flow. This construction shall be equipped with all the needed mechanical and electrical equipment.

- Construct a reinforced concrete structure, similar to the existing screw pumps basin, at both sides of the basin permitting the installation of 7 screw pumps (3 from one side and 4 from another side) and permitting the installation of the related penstocks and access covers.

This additional structure shall include the needed concrete access stairs.

- Install Aluminum handrails where needed for the extended parts.
- Repair concrete where needed in: Stairs, walls, roof slab beside penstocks ...

The major noted defects: Cracks, concrete cover pulled out, exposed and rusted steel reinforcement...

- Repaint concrete faces with appropriate epoxy coating protecting from site environment effects.at the following locations:
  - Inclined walls/stairs faces (L=9.5, h=1.4m)
  - Exterior walls faces (Interior: hmax=4.8m, Exterior: h=1.1m)
- Provide 14 steel gratings/openings covers beside the penstocks (7 units for existing structure and 7 for the extension parts): 12 units 50x125cm, 2 units 75x145cm
- Supply and install aluminum covers for the lifting station area for odor control purposes

Note: The rehabilitation of the existing hand rails is not included in the proposed works since they are involved in the project under implementation by UNICEF.

B.3.14.3.2 Screw Pumps Motors and MCC Building

This building is composed of one room and comprises the electro-mechanical equipment which enable operating the existing 7 screw pumps.

Consequent to the extension of the screw pumps lifting station, the screw pumps motors and MCC building shall also be extended at both sides allowing the operation of the 7 additional screw pumps, 3 at western side and 4 at eastern side.

The required civil works can be summarized as follows:

- Demolish and cart away part of or all the existing structures located in the extension area (Access stairs, access slope, …)
- Construct a reinforced concrete structure, as an extension to the existing lifting station building, at both sides of the basin permitting the operation of the new 7 screw pumps, including all needed earthworks, concrete works, finishing works and MEP works.
- Reconstruct new access stairs and access slope,
- Repair concrete where needed in: Access Stairs, columns, beams, travelling crane supports.
- Repaint exterior concrete faces with epoxy coating.
- Repaint interior concrete faces, including removal of the existing paint.
- Install new tiles for the access stairs, including removal of existing tiles.
- Replace all earthing and lightning system
- Install new lamps and fixtures (14)
- Install new fire extinguishers: One powder type (50kg) and 3 Co2 type (6kg).

Note: The rehabilitation of the hand rails and all metallic outdoor, steel cabinets for electrical control panels, doors and windows and louvers are not included in the proposed works since they are involved in the project under implementation by UNICEF.

B.3.14.3.3 Bar Screens

This area includes concrete channels, steel screens, concrete crossover/pedestrian bridge, permitting to drive the wastewater to the aerated degritting tanks.

This structure does not need to be extended, despite the mentioned above extension of the screw pumps structures. However, it may need to be adjusted to be able to install new fine screens in addition to the existing coarse screen

The required civil works can be summarized as follows:

- Replace pedestrian concrete bridge (Major cracks and apparent steel reinforcement).
- Replace damaged concrete cover slab part above ventilation grill, including removal and reinstallation of the grill, with new anti-mosquito net concrete bridge.
- Repair concrete/plaster where needed in pulled out/cracked on concrete faces and apply needed adjustments to match with the fine screens' replacement.
- Treat/repair and paint rusted steel cover gratings.
- Supply and install aluminum covers for odor control purposes

Note: The rehabilitation of the hand rails is not included in the proposed works since they are involved in the project under implementation by UNICEF.

B.3.14.3.4 Grit Classifiers

Two grit classifiers are installed in two concrete channels, one at each side of the screens.

Based on the process assessment the existing grit classifiers shall be replaced with 2 new stainless steel grit classifiers that will be installed at the same locations.

The required civil works can be summarized as follows:

- Demolish and cart away the existing two concrete grit collection pits and provide civil works, as needed, for the installation of the new grit classifier.
- Or adjust and refurbish the existing two concrete grit collection pits through the needed concrete repair, painting and other needed finishing works.

B.3.14.3.5 Aerated Degritting Tanks

This structure is composed of four uncovered aerated degritting tanks. The aerated degritting tanks shall be rehabilitated and extended by constructing one additional aerated degritting tank, at the eastern side which necessitate to relocate the blower room. Consequently, the blower room shall be demolished and a new building will be constructed at another location.

The required civil works can be summarized as follows:

- Demolish the existing blower room building including:
  - Transport to approved dumping site all the broken/damaged/not useful material or equipment…
  - Any useful material or equipment shall be defined by BMLWE representatives and shall be appropriately stored in the plant, or delivered to them, at other approved stores locations.

Note: Special attention shall be taken in order not to damage the existing equipment/material (Used for Wastewater process or building functionality) that are in good condition and shall be used/installed in the new blower building construction.

- Construct an additional reinforced concrete aerated degritting tank, as an extension to the existing tanks structure, at the eastern side including all needed earthworks, concrete works, finishing works and MEP works.

- Treat and paint rusted steel:
  - Gratings covers for channels
  - Steel rails for mobile bridge, above the concerned walls and at wall side faces and steel fixations.
- Repair concrete at rails fixations (For mobile bridge)
- Replace concrete columns/Pedestals for mobile bridge braking system) (3 units: 50x40x105 cm each)
- Paint internal and external concrete faces
- Install new steel gratings where missing: 20 Units in the existing tanks channels (50x107 cm each)
- Supply and install aluminum covers for odor control purposes

Note: The rehabilitation of the existing hand rails is not included in the proposed works since they are involved in the project under implementation by UNICEF.

B.3.14.3.6 Blower Room Building

This building is composed of one room, housing three blowers, including all the related electro-mechanical equipment.

As explained in the above section, the existing blower room shall be demolished and relocated due to the extension of the aerated degritting tanks. Therefore, a new building, with similar dimensions, shall be constructed in other location, including all needed earth works, finishing works, MEP works, ….

To be highlighted that some of the existing equipment is in good condition; therefore, they shall be adequately dismantled before demolishing, stored and reinstalled in the new location.

B.3.14.3.7 Main Pumping Station Building

The main pumping station building encloses, in addition to the electro-mechanical pumping system, a laboratory and an operator office room.

Knowing that the rehabilitation works INSIDE this building related to the concrete repair and painting and the full rehabilitation of the laboratory are involved in the project under implementation by UNICEF, therefore the proposed civil works rehabilitation will cover mainly the EXTERIOR elements of the building, in addition to some equipment for inside the building.

Noting especially, that the reinforced concrete roof parapet is in bad condition.

The required civil works can be summarized as follows:

- Repair concrete where needed in the exterior aspects: Columns, walls.
- Demolish and reconstruct the concrete roof parapet. In fact, the parapet is too much damaged. Significant pulled out concrete cover exposing rusted steel reinforcement in large areas. So, it is proposed to demolish all the parapet and reconstruct new parapet, starting from the roof ceiling level, excluding the current downward parapet extension.
- Repaint exterior concrete faces with epoxy coating.
- Repair/extend concrete roof drainage (Broken) beyond the parapet faces.
- Extend roof waterproofing to above parapets including repair, where needed if any, ensuring appropriated waterproof connection with existing membrane.
- Replace lamps and fixtures (15 units)
- Replace all earthing and lightning system

- Replace defected AC: 4 units: 24000 btu, 1 unit: 9000 btu
- Replace all ventilation and ducting system in Pumps building including the related roof equipment (Defected ventilators and rusted ducts).
- Dismantle old/rusted fire extinguishers and install new fire extinguishers: One powder type (50kg) and 9 Co2 type (6kg).

Note: The rehabilitation works inside this building related to the concrete repair and painting and the full rehabilitation of the laboratory, in addition to the rehabilitation of all metallic outdoor, steel cabinets for electrical control panels, doors and windows and louvers are not included in the proposed works since they are involved in the project under implementation by UNICEF.

B.3.14.3.8 Transformers and Generators Building

This building is composed of two separated rooms. One room at the northern side comprises two transformers and another bigger room at the southern side contains three generators, small fuel tanks and several electrical panel boards. The building is generally in good structural condition.

An additional fuel stockage has been ensured through three fuel tanks, located outside the building, having a capacity of 15m^3 each. However, these tanks are out of service and they shall be replaced with new fuel tanks with same capacities, and relocated at different location (Refer to 3.14.3.12 – Exterior works)

To be noted that the transformers room includes also various materials and equipment not related to the transformers' usage. They all shall be removed to an approved storage area or installed and put in service where needed. This room shall be strictly used for electrical operation and maintenance related to the transformers and firmly shall not be used as a storage room.

The required civil works can be summarized as follows:

- Minor concrete repair works where needed, …
- Repaint exterior concrete faces with epoxy coating
- Repaint interior concrete faces, including removal of the existing paint.
- Treat and paint rusted steel fuel tanks, …
- Replace all earthing and lightning system
- Replace lamps and fixtures (25 units)
- Replace solid steel channels covers: 10 units (110x96 cm each).
- Treat and paint rusted steel channels covers.
- Install new fire extinguishers: One powder type (50kg) and 6 Co2 type (6kg).

Note: The rehabilitation of all metallic outdoor, steel cabinets for electrical control panels, doors and windows and louvers are not included in the proposed works since they are involved in the project under implementation by UNICEF.

B.3.14.3.9 Old Consultant Building

The old consultant building was erected outside the plant fence during the plant construction as "Consultant Office". This building is the property of BMLWE but is not in use since the plant construction.

This building is not safe for access inside. It is always closed and the plant operator does not allow anyone for the access inside.

Based on site inspection, from outside the building and through the opened widows, the following is noted:

- The roof slab is totally damaged. Major deflections inside and significant pulled out concrete cover showing important areas of rusted steel reinforcement layers. The roof slab is supported on the external hollow blocks walls but not supported on the internal walls' partitions.
- The false ceiling is defected because of ceiling damages.
- The internal finishing needs almost total refurbishment for any rehabilitation purpose.

Therefore, it is proposed to totally dismantle this building, excluding any building construction at the same location, since it is located outside the plant fenced area. However, an uncovered parking area is proposed at this location.

Consequently, the required works are:

- Demolish the existing construction and transport to approved dumping site all the broken/damaged/not useful material or equipment …
- Any useful material or equipment shall be defined by BMLWE representatives and shall be appropriately stored in the plant, or delivered to them, at other approved stores locations.
- Because of the current danger structural condition, special safety measures shall be provided, while removing any equipment/material and while demolishing.
- Achieve the needed road construction and finishing works for an uncovered parking area.

B.3.14.3.10 Parking Structure

The parking structure, located beside the guard house, covers an area of about 50 m^2 (10mx5m) and is composed of 6 circular concrete columns (Diameter=25cm, h= 220cm) supporting transversal and longitudinal grid of concrete beams (Cross Section: h=50cm, b=25cm). The concrete beams are specifically in bad condition, having many defects in the concrete and reinforcement, and they are not covered by any shading material. (Currently cut palm branches are temporarily installed).

This parking area shall be rehabilitated including complete system and a new shaded parking area shall be implemented providing a total capacity of 16 vehicles.

The required civil works can be summarized as follows:

- Demolish all reinforced concrete beams: Pulled out concrete cover, cracks, apparent rusted steel reinforcement in many locations.
- Repair concrete in the columns in some locations: Pulled out concrete cover, cracks, apparent rusted steel reinforcement.
- Construct new reinforced concrete beams, supported by the columns.
- Construct a new steel structure with shading material supported by the concrete beams.
- A new uncovered parking area shall be provided to accommodate a total 16 vehicles (At the location of the old consultant offices, to be dismantled).

B.3.14.3.11 Guard House

The guard house rehabilitation is a part of the rehabilitation works undertaken by UNICEF, who will perform complete rehabilitation for the guardian house building including all type: Civil, painting mechanical and electrical works.

Therefore, no woks will be proposed for the Guard House.

B.3.14.3.12 Exterior Works

The plant area limited by the constructed fence contains a vast non constructed surfaces which is composed of roads and non-planted soil, separated by concrete curbstones.

The non-planted area is currently used as storage for materials and equipment: (Pipes, generators, fuel tanks, containers, …)

Referring to the current upgrading design, the non-planted area will be exploited by constructing additional buildings fulfilling the required project needs.

The rehabilitation of the current concrete fence and the main steel gate are involved in the rehabilitation works undertaken by UNICEF project.

Therefore, the exterior works shall include the following:

- General cleaning and rearrangement inside all the plant area. The non useful materials or equipment shall be removed and transported to approved dumping site, while the useful material or equipment shall be defined formally by BMLWE representatives and shall be either gathered in a specific storage area inside the plant or formally delivered to them, at outside approved stores locations.
- Demolish and cart away the exiting 3 fuel tanks having a capacity of 15 m^3 each
- Install new 3 fuel tanks, replacing the existing tanks, with same capacities, including:
  - Reinforced concrete pad
  - Fuel containment
  - Steel structure with shading cover.
- Install new curbstones, where needed: New, or replacing defected parts or replacing that will be damaged during construction.
- Install new tiles where needed: New, or replacing defected parts or replacing that will be damaged during construction.
- Repair concrete where needed, in open area: Curbstones, ground slabs, manholes cover slab, parapets, …
- Repaint exterior concrete faces with epoxy coating where needed, in open area.
- Treat, repair if any, and paint rusted steel gills and opening covers.
- Maintenance of Security/Control cameras, including needed partial replacement
- Replace exterior lighting projectors with new waterproof projectors, solar powered (20) and Led Projectors (10)
- Plantation of grass inside areas limited by the curbstones: beside fence and around constructions.
- Plantation of trees: around 50 units (Palm, pin, cypress, juniper, …)
- Asphalt reinstatement for the all the internal access roads.

B.3.15 Architectural Design

B.3.15.1.1 Context

The location of existing and proposed sites of the Waste Water Treatment Plant in Expansion and Upgrade of Al-Ghadir WWTP Project is very delicate in terms of its geographical context, being close to the Airport facilities and not far from Beirut City.

All the constructions shall comply with the airport regulations, ensuring safe airplanes maneuvering, especially regarding the allowable height.

In addition, acceptable good-looking architecture shall be provided, in order not to affect the view and the impression of the passengers, particularly to be integrated, as possible, with Beirut sight.

B.3.15.2 Functions of Technical Equipment and Staff Rooms

In his design, the Contractor shall indicate the arrangements he intends to make with respect to the following:

- Visual comfort: natural lighting in all work rooms, protection against sunlight for all exposed facades, good electric lighting provided by low-luminance quality fixtures.
- Acoustic comfort: soundproofing of all partition, exterior and interior walls and floors. Noise absorption of ceilings and walls to prevent noise reverberation.
- Thermal comfort: air-conditioning and heating in order to maintain a temperature of 20-25°C.
- Ease of maintenance: stoneware or similar flooring, washable walls, good-quality joinery both indoors and outdoors.
- It must be possible to modify interior distribution systems in each sector with the minimum amount of work.

All furniture supplies shall meet the following requirements:

- Modern functional design adapted to the architecture and indoor arrangements.
- Ergonomic design for operating rooms.
- Standard quality for staff and other rooms.
- Harmonization with supervision and control equipment in the control room.

The supplies shall be sufficient to enable the plant to commence operation immediately. They shall be adapted to the architecture and use of the rooms in question. They shall comply with the following principles, which shall be adapted in accordance with the architecture proposed by the Contractor.

B.4 TESTS ON COMPLETION OF DESIGN-BUILD

B.4.1 Commissioning Activities

B.4.1.1 General

With regard to Clause 11.1 of the General and Particular Conditions of Contract, the Tests on Completion shall satisfy the following:

- Pre-commissioning tests: inspections prior to flooding to determine whether the installations are in fact ready to be commissioned.
- Permission for flooding given by the Engineer
- Adjustment period lasting 60 days, during which the Contractor finalizes the installations under operation. Commissioning tests end this period.
- Trial Observation period lasting 90 days, for checking that continuous operation complies with the basic design and performance requirements. Performance tests are carried out during this period. The observation period shall not end until correct operation has been observed for a period of 30 consecutive days.
- Commissioning certificate of the plant upon completion of the works, construction, finalization and adjustments and especially after commissioning of the Performance Tests.

B.4.1.2 Pre-Commissioning Tests

The installations should be in working order and all checks and pre-commissioning tests relating to the civil works and equipment have given satisfaction. The CTM control unit is working properly and the electrical installation has been certified by the authorized agency.

The site installations have been dismantled, the sites cleaned, roads completed and green spaces planted.

The complete operation and maintenance manual, final maintenance plan and test plan for downgraded operation mode have been supplied by the Contractor.

In these conditions, the Contractor shall give the 21days notice for informing the Engineer of the Date after which the Contractor shall ready to carry out the pre-commissioning tests.

Within a period of 14 days, the installations shall be inspected with a view to checking that they have been built correctly and in conformity with the Employer's requirements and the design.

On conclusion of this inspection, the Engineer shall notify any observed omissions, imperfections or poor workmanship. The same document shall indicate whether the installation can be flooded (start of the adjustment period) in spite of these imperfections and poor workmanship or whether it is postponed until they have been rectified. In the former case, the Contractor shall have 15 days "modification period" and a new notification shall be sent to the Contractor to note that these imperfections and poor workmanship have been remedied, at which point the adjustment period begins.

The Contractor shall bear the risk of extra-costs and penalties related to the new 15 days modification period

B.4.1.3 Adjustment Period

The adjustment period begins on the date of flooding's authorization of the installations notified by the Engineer.

This period allows the Contractor to carry out all the checks and adjustments that he considers necessary and to ensure that there are no construction faults in the civil works and equipment.

This period shall last sixty (60) days.

The Engineer shall be informed of all checks and adjustments, all analysis and inspection results in a file kept regularly up to date, in two copies.

During the adjustment period:

- The installation shall be operated under the authority and responsibility of the Contractor: all necessary adjustments, repairs and modifications shall be made by him at his own expense.
- The cost of all electrical energy, fluids and consumables, including reagents required for the correct operation of the plant, shall be borne by the Contractor.

As soon as flooding takes place and during all the duration of the adjustment period, the Contractor shall train the future operating staff of the instructions for operating and maintaining the installation, based this on the operating manual provided prior to flooding. The Contractor shall draw up a staff training schedule in liaison with the Employer and with his approval.

This is updated throughout the adjustment period. In any case, the Contractor shall be responsible for the operation and maintenance of the plant. The trained Employer's staff shall not have any responsibilities in the management of the plant

Specific periods for staff training must be organized outside the plant. The length of these periods is to be indicated in the contractor proposal.

Not later than 50 days after the beginning of the period or as soon as the Contractor considers the installation to be in good working order, he shall inform the Engineer in writing that the observation period can begin.

Provided that the various investigations carried out during the adjustment period indeed confirm that the installation is in good working order, the Engineer will notify that the plant succeed to pass the Commissioning tests.

Then, the Engineer will require the Employer for giving in writing the observation period within ten (10) working days of the date of the Contractor's request.

Should the plant fail to be in good working order, in the opinion of the Engineer, a new 15 days "modification period" shall be given to the Contractor to achieve the works. The Contractor shall bear the risk of extra-costs and penalties related to the new 15 days modification period.

B.4.1.4 Trial Operation Period

The Trial Operation period runs for a duration of 90 consecutive days without the installation being stopped.

The aim is to verify that the installation is complying with the Guaranteed Performances and with the Employer's Requirements under continuous working conditions and to assess the operating conditions, particularly with regard to energy and reagent consumption.

During the Trial Operation period, the Contractor shall carry out Performance tests at his own expense.

The Employer shall have full authorization to have a new series of tests carried out at his own expense prior to acceptance in order to check that the Contractor has fulfilled all his obligations in terms of the quality of treatment, production of residues, electricity and reagent consumption, operation of the installations, miscellaneous types of disturbance, etc.

During the Trial Operation period:

- The installation shall be operated under the authority and responsibility of the Contractor. All necessary adjustments, repairs or modifications are carried out by him and at his expense.
- The energy, fluids and consumables, including reagents, are provided by the Contractor and included in his Price.

In light of the results of all the checks carried out, and in particular those of the Performance tests, the Employer may ask for the observation period to be extended to enable the Contractor to remedy any malfunctions responsible for the observed inadequacies or problems. Penalties for delay may be applied. The cost of additional tests required to ensure that the Contractor has complied shall be borne by him.

The Trial Operation period can be terminated only after a period of 30 consecutive days of proper operation of the installations.

B.4.1.5 Performance Tests

Performance tests are carried out during the observation period. Their aim is to determine the capacities of the treatment process, the quality of treatment, the efficiency of the various structures and items of equipment, and energy and reagent consumption in normal operating conditions.

The performance tests are carried out by an organization that is independent of the Contractor, approved by the Employer and monitored by the Engineer.

The tests are determined on the basis of the protocol given below, if necessary, adapted by the Contractor and submitted to the Engineer for approval.

During the test period, the installation is operated by the Contractor with its staff assigned to the operation.

The Contractor shall bear the cost of electrical energy, fluids and consumables (including reagents), which shall be included in his Price.

The organization in charge of carrying out the tests is responsible for setting up and removing the temporary installations required for the tests.

The costs of carrying out the tests shall be borne by the Contractor.

If the results of the tests are not satisfactory, the Engineer shall notify the Contractor concerned that he must remedy all the observed inadequacies and malfunctions without delay.

When all the results are satisfactory, a test conformity report is drawn up and signed by both parties.

B.4.1.5.1 PERFORMANCE GUARANTEES

Specific guarantees with respect to the capability of the plant to meet the specified treated wastewater effluent criteria, as well as the dewatered sludge characteristics, are required from the Contractor as part of this Contract. The Contractor shall coordinate with the Employer's Representative to ensure that the Performance Tests are successful. The Performance Guarantees tests when successfully completed shall be the basis for issuing the Performance Certificate. The Performance tests shall be carried out during the 24 months of the operation and maintenance period following the issuance of the Partial Completion Certificate as detailed below.

The Performance Tests shall be carried for a total of four separate 28-days periods, one in each season of the year. For the purpose of this contract, the seasons shall be defined as follows:

Season	**Calendar Months**
Spring	March, April, May
Summer	June, July, August
Fall	September, October, November
Winter	December, January, February

The last Scheduled Performance Test shall be scheduled to conclude 28 days prior to the end of the Defects Liability Period.

During the Performance Tests Periods, daily 24-hours flow-weighted composite samples of the final effluent shall be taken with sampling every 2 hours. Relevant action shall be taken to secure accurately

measured concentrations and continuously collected reserve samples. The composite samples shall be analyzed for BOD_5, Total Suspended Solids (TSS), Total Nitrogen (TN) and Total Phosphorus (TP) and shall be compared with the relevant values of the flow- weighted values of samples taken from the incoming raw wastewater at the inlet works in order to determine the efficiency of the treatment plant. (Knowing that TN and TP are for reference only and parameters treated in the Phase I).

None of the composite samples from the final effluent shall exceed the specified treated wastewater effluent criteria.

The dry solids of the sludge shall be measured daily. No sample of the sludge cake taken shall show a dry solids content of less than 20 %. In addition, the sludge quantity of the dewatered sludge shall be determined daily.

In case of failure to meet any of the required effluent quality for any period of time, the Defects Liability Period and the operation and maintenance period will be extended by the failure period of time and entirely at the expense of the Contractor.

A failure to meet any of the required effluent quality for a period of time exceeding 3 weeks (not necessary 3 consecutive weeks) will result in extending the Defects Liability Period and the operation and maintenance period by a period of 3 months and this entirely at the expense of the Contractor.

A failure to meet any of the required effluent quality for a period of time exceeding 6 weeks (not necessary 6 consecutive weeks) will result in extending the Defect Liability Period and the operation and maintenance period by a period of 6 months and this entirely at the expense of the Contractor.

A failure to meet any of the required effluent quality for a period of time exceeding 10 weeks (not necessarily 10 consecutive weeks) will result in re-starting a 12 months operation and maintenance period and a 12 months Defects Liability Period as of the date when the required effluent standards are met and this entirely at the expense of the Contractor.

B.4.1.5.2 Treated Wastewater Effluent Quality Guarantee

The Contractor shall guarantee that the effluent leaving the wastewater treatment plant complies at all times, under design flow and influent wastewater characteristics conditions with the specified treated wastewater effluent quality. In addition, the Performance Tests shall meet the treated wastewater effluent quality guarantee.

B.4.1.5.3 Electrical Power Consumption Guarantee

The Contractor shall guarantee that the net power consumption (i.e Total Power Consumption less the Power Generated from Biogas) given with his Tender are not exceeded. Tests for electrical power consumed/produced will be the basis of the power used in specific test runs during the Performance Tests carried out during the period of Performance Testing. The measured net electrical consumption during each performance testing will be multiplied by the ratio of 365/28 to derive the corresponding yearly consumption and will be compared to the guaranteed consumption to assess the passing or failure of the Performance Tests.

B.4.1.5.4 Chemical Consumption Guarantee

The Contractor shall guarantee that the chemical consumptions given with his Tender are not exceeded. Tests for chemicals consumed will be on the basis of the chemicals used in specific test runs during the Performance Tests carried out during the one-year period of Performance Testing. The measured chemical consumption during each performance testing will be multiplied by the ratio of 365/28 to derive the corresponding yearly consumption and compare it to the guaranteed consumption to assess the passing or failure of the Performance Tests.

B.4.1.5.5 Non-Compliance Penalties

In case the specified quality of the treated effluent is not maintained with respect to the BOD_5 concentration, the Contractor will be charged on the basis of the 24-hours flow-weighted composite samples as follows:

BOD_5

The daily excess of the BOD_5 load in tons, calculated as the positive difference between the actual load and the admissible load, calculated on the basis of the specified quality and the actual flow figure, shall be taken as the base and charged, dependent on the percentage of excess, with:

Excess of BOD_5 load	**Fee per excess ton of BOD_5**
0 % to less than 25 %	1,000 USD
25 % to less than 50 %	2,000 USD
50 % and more	3,000 USD

Dewatered Sludge

In case the specified dry solids content of the dewatered sludge is not maintained, the Contractor will be charged on the basis of the dry solids content of the sludge as follows:

The daily excess of the sludge cake quantity in m3, calculated as the positive difference between the actual quantity and the admissible quantity, calculated on the basis of the admissible and the actual dry solids content, shall be taken as the base and charged, dependent on the actual dry solids content with:

Dry Solids content of sludge cake	Fee per excess m^3 of sludge cake
15 % and less	100 USD
16 % to less than 20 %	50 USD

Net Power Consumption

In case of failure to meet the guaranteed net power consumption given in his tender, the Contractor shall pay the Net Present Value of the additional cost to the Client resulting from the excess power consumption over 20 years operation calculated at average daily design flow and design wastewater loadings. A discount rate of 6% shall be used in the Net Present Value calculations.

Chemicals Consumption

In case of failure to meet guaranteed chemicals consumption given in his Tender, the Contractor shall pay the Net Present Value of the additional cost to the Client resulting from the excess chemicals consumption over 20 years operation calculated at average daily design flow and design wastewater loadings. A discount rate of 6% shall be used in the Net Present Value calculations.

B.4.1.5.6 Performance Certificate Guarantee

A Performance Certificate will be issued by the Employer's Representative in accordance with the applicable clause of the General Conditions of Contract following the successful completion of all Performance Tests where all performance guarantees are met at the end of the Defects Liability Period.

B.4.1.6 Commissioning Certificate

At the end of the trial observation period, provided that it shall be successfully and only if the Performance tests are satisfactory, the Commissioning Certificate will be issued in accordance with Clause 11.5 of the General Conditions of Contract.

SECTION VII – EMPLOYER'S REQUIREMENTS

PART C: CONTROL OF PERFORMANCE LEVELS FOR WWTP

SECTION VII – C: CONTROL OF PERFORMANCE LEVELS FOR WWTP

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C.1 TEST PROTOCOL

C.1.1 Wastewater Treatment

C.1.1.1 General Procedures

a) Tests with reference load

Tests shall be carried out for 7 consecutive days.

The installations must be tested in conditions that are as close as possible to the nominal situation defined in the Performance specifications.

If this is not the case, special arrangements may be made. For example, if the load and volume to be treated are insufficient, the tests may be conducted on a single line. However, in this case, the tests must be repeated on the other line(s).

Should it prove impossible to fall within the guaranteed treatment range, even with only part of the installation operating, partial tests shall be carried out prior to commissioning the installation as per the indications given in section 1.7.

b) Tests at maximum flow

During the Trial operation, or failing that during the year of guarantee, tests shall be performed to check the guaranteed performance levels under maximum flow.

C.1.1.2 Flow Rate Measurements

All measurement instruments shall be checked and rated and a rating certificate provided.

Continuous discharge measurements, with graphic recordings, shall be performed at the following points:

- At the plant headworks: metering of wastewater inflow.
- Metering of treated water prior to discharge.
- By-pass if any
- Return water from the internal sewerage network
- Sludge Flows
- Gas flows

The sludge recirculation (when applicable) flow must be checked continuously, either directly by using the metering instruments provided for this purpose, or indirectly by operating the pumps.

C.1.1.3 Quality of Treatment

The temperature of wastewater entering the treatment plant shall be checked.

Twenty-four-hour flow-proportional composite samples shall be collected each day in the following points:

- on untreated wastewater at the inlet
- after primary sedimentation
- after secondary treatment (when applicable)
- on treated wastewater.

Each sample shall be analyzed for the following parameters:

- COD, BOD5, TKN, TP, SS, pH, conductivity, turbidity

Automatic samplers shall be installed at the mentioned points.

C.1.1.4 Checking the Operation of Certain Structures

Various measurements and checks are performed to assess the operation of individual structures.

The test protocol shall be proposed by the Contractor and approved by the Engineer. The Contractor shall provide intermediate inspection parameters for assessing the proper operation of the structures, for example localized inflow/outflow samples, sludge characteristics, etc.

The test protocol shall include the following points in particular:

a) Grease and oil traps

Two localized samples are taken upstream and downstream of the structure, and the quantity of hexane-extractable material (HEM) analyzed.

Part of the upstream sample is subjected to dissolve air flotation in the laboratory, lasting at least 2 hours.

The elimination rate obtained in the laboratory is taken as a standard. The efficiency observed in the field is expressed as a percentage of the laboratory rate (the field "efficiency" may even be above 100%).

b) Preliminary treatment waste

A sample of the following waste is taken each day:

- Screening rejects following compaction.
- Grit after washing and centrifuging.

The dry matter and volatile matter content of each sample is analyzed.

The quantities produced are measured each day and expressed in m3 and kg of dry matter.

c) Reagent consumption

The consumption level must be measured daily on any treatment process involving the addition of reagents.

d) Primary Clarifier

- Daily measurement of TSS
- Continuous recording of primary sludge pumping

e) Biological reactor (when applicable)

- Daily measurements of MLSS levels in the bioreactor
- Continuous measurement of Dissolved Oxygen Level
- Daily measurement of NO3-
- Daily measurement of NH4+

f) Grease treatment

One grab sample per day shall be taken at the inlet and the outlet and shall be analyzed for HEM, COD and TSS.

C.1.2 Sludge Treatment

Tests are to be carried out for a period of 7 consecutive days at the same time as the water tests.

The production of primary, biological must be measured (where applicable).

The quantities of sludge must be noted at each stage (thickening, digestion, dewatering, lime addition) and if necessary for each type of sludge.

Six localized samples per day must be taken at each stage of treatment.

The quantities of reagents consumed must be noted.

Localized samples of all types of drippings (overflow, filtrates, centrifugates, etc.) must be taken at least twice a day.

The analyses shall be performed on daily mean samples obtained by mixing the individual samples, and shall concern the following parameters:

- fresh liquid primary sludges: SS, VSS, dryness, pH, redox,
- thickened primary sludges: SS, VSS, dryness, pH, redox,
- Digested Sludge: SS, VSS, dryness, pH
- dewatered sludges: SS, VSS, dryness, pH,
- lime treated sludges: dryness, pH, lime content
- for each type of dripping: SS, BOD5.

Reagent consumption must be noted.

The real hourly nominal capacities of the various components of the sludge treatment line must be checked, and the capture rates and sludge production ratios calculated.

The slump of limed sludge must be checked.

C.1.3 Air Extraction and Odor Treatment

Performance tests shall be carried out on site.

The quality of the air extraction and odor treatment system shall be checked by an inspection organization.

At least two series of air samples shall be taken by them during the test period, on 2 separate days.

The samples shall be taken during the period of most intense activity, for example during or just after the peak discharge period. All the installations, in particular those involved in sludge treatment, shall be in operation.

All air distribution and removal devices inside the premises shall be set correctly. All openings other than those intended to admit fresh air must be closed.

The inspection shall also include a check of the air flow rates.

The sampling techniques shall comply with standard NF X 43.104.

Each series of samples shall cover the following points:

- Operating premises

The number of sampling points in operating premises shall be chosen in agreement with the Engineer, so as to obtain an average representation of the atmosphere in the room and an average sample per area will be obtained by mixing the various individual samples. The analyses will concern the levels of H2S, NH3 and methyl mercaptans.

The air flow in each airduct > 200mm shall be measured, particular previsions are made for ensuring that the sampling device will not by itself affect the result

- Odor treatment

At least two samples of polluted air entering the deodorization system and of treated air leaving the treatment system shall be taken per series of tests.

The analyses performed on the samples of air entering and leaving the deodorization system shall concern the specific gases that are to be treated, as defined in the Performance specifications.

The elimination rate shall be calculated for each gas that is to be treated.

- Odor level at the edge of the property

Two samples of air per series of tests and per site shall be taken at the edge of the property. The sampling points shall be chosen in agreement with the Engineer. The analyses shall concern the gases for which maximum thresholds are defined in the Performance specifications.

C.1.4 Checking of General Operation

C.1.4.1 Energy Consumption

Active and reactive energy consumption shall be measured each day for the plant as a whole and for each of the main components. Voltage, Intensity and CosΦ shall be carried out in order to check the power of each equipment and for the whole installation.

C.1.4.2 Drippings and Septage

The total volume of drippings and added septage shall be recorded each day. The corresponding pollutant loads must be measured each day.

C.1.4.3 Other Points to be Noted

- Consumption of all reagents.
- Working time of the main items of equipment: lifting, aeration, recirculation, air extraction, thickening and centrifugation.
- Ventilation rate on each line and operating pressure.
- Measurements of power consumption by equipment: compressor, stirrers, centrifuges, etc.

C.1.5 Noise

- At the edge of the property

During the tests, an overall measurement of the noise emitted by the installation shall be carried out at the edge of the property. The measurement shall be made by an organization approved by the Engineer and in accordance with the conditions set out in standard NF S 31.010.

The measurement point shall be chosen in agreement with the Engineer.

The measurement shall be carried out for a period of 24 hours, during which the installation shall be in normal operation, in conditions that are as close as possible to nominal working conditions.

- Within the premises (at the plant)

The appropriate measurements shall be performed to ensure that the arrangements made by the Contractor comply with regulations concerning the safety of staff and with the guarantees provided by the Contractor.

C.1.6 Partial Tests

These tests concerning certain structures shall be performed when the overall tests cannot be performed completely. The Engineer may order them in application of section 1.1.1 above.

These partial tests could involve checking of:

- the performance of the ventilation system,
- the performance of the clarifiers,
- the performance of the sludge dewatering system.

C.2 INTERPRETATION OF RESULTS

C.2.1 Quality of Wastewater Treatment

With regard to the parameters COD, BOD5 and TSS, the results obtained for each daily mean sample must comply with the requirements of the Performance specifications.

A value that exceeds the standard by less than 10%, on the basis of the average for the test period, shall not justify refusal of the installation. However, the Contractor must provide justification for the results obtained and provide proof that he will nevertheless be able to achieve the target annual average.

If such proof appears to be insufficient or if the value is too high in comparison with the standard, the Engineer may require the Contractor to modify the installation at his own expense. New tests shall then be performed during the guarantee period at the Contractor's expense to demonstrate that he has taken the right measures.

In any event, if the target has still not been attained at the end of the guarantee period, the Contractor shall modify the installation at his own expense, and a new guarantee period of one year shall commence at the end of the corresponding work. The performance tests shall then be carried out at the Contractor's expense.

C.2.2 Quality of Sludge Treatment

C.2.2.1 Quality

The dryness of unlimed and limed dewatered sludge and the slump of limed sludge shall at least comply with the requirements set out in the Performance specifications, without any addition of reagent higher than that stipulated in the contract in the corresponding operating conditions.

C.2.2.2 Sludge Production

- The mean sludge production ratio shall be calculated over the test period. In calculating this mean ratio, no account shall be taken of days with a higher intake than the reference loads. The mean ratio shall be no higher than that specified in the Schedule of Guaranteed Performances.
- The daily maximum production of sludge during the test period shall be no higher than that specified in the Schedule of Guaranteed Performances, irrespective of the load received.

C.2.3 Quality of Odor Treatment

The levels of NH3, methyl mercaptans and H2S inside the operating rooms shall comply with the labor legislation in force at the time of signing the contract.

Concentrations in samples collected at the outflow from the gas deodorization system shall comply with the levels set out in the Performance specifications.

Concentrations in samples collected at the edge of the property shall comply with the levels set out in the Performance specifications.

C.2.4 Energy and Reagent Consumption

The results of energy and reagent consumption measurements must comply with the Schedule of Guaranteed Performances.

However, without affecting the validity of the tests, the following tolerances will be allowed for excess consumption:

- Biogas generation 10%
- electrical energy 5%
- reagents: 10%

Consumption shall be assessed over the entire test period.

C.2.5 Noise

The results of general noise level measurements at the edge of the property and in the premises must comply strictly with the Performance specifications.

C.2.6 Quality of Screenings and Washed Grit

The quality of compacted screenings and washed grit must comply strictly with the Performance specifications for each daily sample.

C.2.7 Checking of Grease Trap Efficiency

Tests performed to check the efficiency of the grease trap shall be deemed to comply if the efficiency observed on the installation represents at least 80% of the efficiency observed in the laboratory.

C.3 Price Reductions for Failure

In accordance with the results of the Performance Tests or other tests performed during the Trial Operation Period, the Employer may apply the following price reductions for failure for over-consumption beyond certain tolerances, the amount of these price reductions for failure being defined in the Particular Conditions – Special Provisions.

C.3.1 Electricity

For loads measured at the time of the tests, a tolerance of 5% is allowed with the respect to the Schedule of Guaranteed Performances.

A price reduction for failure may be applied for over-consumption between 5% and 10%, as defined in the Particular Conditions – Special Provisions.

Any over-consumption of more than 10% will lead to the installation being rejected.

C.3.2 Chemicals

For consumption measured at the time of the tests a tolerance of 10% is allowed with respect to the Schedule of Guaranteed Performances without any penalty.

A price reduction for failure may applied for over-consumption between 10% and 20%, as defined in the Particular Conditions – Special Provisions.

Any over-consumption of more than 20% will lead to the installation being rejected.

C.4 REJECTION OF THE INSTALLATION

Should the Contractor fail to satisfy the requirements under which the works can be accepted, the Employer may reject the faulty installations and apply the coercion measures provided for in the General Conditions of the Contract.

SECTION VII – EMPLOYER'S REQUIREMENTS

PART D: OPERATION AND MAINTENANCE REQUIREMENTS FOR WWTP

SECTION VII – D: OPERATION AND MAINTENANCE REQUIREMENTS FOR WWTP

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D.1 SCOPE OF THE OPERATION SERVICE PERIOD

The Contractor shall be responsible for Operation Service Period of two (2) years after the end of the Contract. During the Operation Service Period, the Contractor shall operate the Works in such a way that the attainable performance criteria are achieved and maintained at all times.

During the Operation Service Period, the Contractor shall additionally provide on-site training of the Employer's staff in managing for the last year of the Contract, operating and maintaining the Works.

The method statement and program submitted with the Contractor's Tender shall form the basis of the Contractor's procedures for Operation Service Period and shall be used to establish a set of standard operational procedures for the Works. Prior to the end of the Contract, the following documents shall be prepared by the Contractor and approved by the Employer's Representative, being produced in a user-friendly style and in a format suitable for use in training the Employer's staff in the Operation and Maintenance of the Works:

- Resource Allocation Statement: Description of staff, materials, plant and equipment required for operating and maintaining the Works.
- Resource Allocation Program: Bar chart schedule for the periods of use of staff, materials, plant and equipment.
- System Development and Implementation Plan: Management of administration, operation, maintenance and technical services.
- Operations Plan: Operation of the Works under normal operation conditions and in cases of outage.
- Maintenance Plan: Maintenance procedures to ensure the continuous operation of the Works under normal operation conditions and in cases of outage.
- Comprehensive Safety Policy: Definition of the Contractor's responsibilities regarding safety and health of all authorized people being situated at the Site.
- Standard Procedures Document: Step-by-step implementation procedures for the effective management and operation of the Works.

The training program shall be submitted for the approval of the Employer's Representative at least two (2) months before the actual start of the Training Period.

This Operation Service Period shall include, but not be limited to the following services:

- management,
- provision of manpower,
- provision of electricity and chemicals,
- provision of fuel, lubricants and consumables,
- payment of penalties, damages, levies and other dues in order to comply with all appropriate regulations and the Contract,
- provision of vehicles,
- provision of spare parts,
- operation of the Works,
- adjustment of process whenever necessary,
- preventive and routine maintenance,
- repair and replacement work,
- repainting work,
- monitoring of performance,
- reporting,

- data filing and processing,
- preparation and execution of training.

The performance of the treatment plant shall be monitored as described in Sub-Clause 5.2, and shall consider the alterations approved by the Employer's Representative during the Performance Tests Periods and the Operation Service Period.

At the end of the Operation Service Period, the Contractor shall hand over the Works to the Employer in fully functional conditions with all necessary maintenance, repainting, spare parts, repair and replacement works having been done to the satisfaction of the Employer's Representative.

All cost in relation to Operation Service Period shall be borne by the Contractor. He shall be liable for any damage of objects and persons caused by faults in operation, maintenance and staff training.

D.2 ADMINISTRATION

D.2.1 Facilities and Equipment

Unless otherwise specified, the Contractor shall provide the facilities and equipment required for a proper functioning of the Operation Service Period, before starting with the Operation Service Period.

During the Operation Service Period, the Contractor shall make use of the following existing facilities and equipment provided during the construction period:

- the wastewater treatment plant,
- any kind of infrastructure,
- treated wastewater discharge pipe,
- administration building including offices, equipment and facilities,
- workshop including equipment and stores,
- laboratory including equipment and facilities,
- mobile equipment,
- spare parts.

The Contractor shall hand over the facilities and equipment complete and in good condition at the end of the Operation Service Period.

D.2.2 Staff

D.2.2.1 Organization

The work program, organization chart, number of manpower and job descriptions of all staff necessary for O&M Period as submitted by the Contractor with his Tender will form the basis for the organization of the services. It may, however be amended by the Contractor to meet the requirements of these services to the approval of the Employer's Representative. Additionally, CVs shall be submitted of the proposed professional staff.

To this regard, before the end of the Design-Build Period, the Contractor shall submit to the Employer's Representative, for approval, a fully detailed work program for Operation Service Period of the Works. This shall include an organization chart with number and job descriptions for each grade of staff up to and including the Plant Manager.

In order to accomplish the approved work program, the Contractor shall provide all expertise, staffing and labor being necessary for a continuous efficient performance of O&M Period. The operation activities shall be programmed and operated accordingly in close co-operation with the Employer's Representative and, if present, with other Contractors.

Staff and labor shall include, but not be limited to the following categories:

- project manager,
- section managers,
- qualified engineers and experts,
- qualified technicians,
- clerical staff,
- semi-skilled labor,
- unskilled labor,
- security personnel.

The selected staff shall be physically and mentally competent to perform the work required of them and shall possess the necessary ability for specific assigned tasks. Any staff not having the requisite qualifications and abilities shall be substituted, at the cost of the Contractor, within one month after requested by the Employer's Representative.

The senior personnel shall be able to read, write and converse in English and, preferably, in Arabic.

The Contractor shall provide proper round the clock attendance and especially day-and-night availability of the key personnel. All absence of key personnel on leave shall be compensated by temporary replacement with adequate staff members.

The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for his labor and staff.

D.2.2.2 Personnel Relations

Cultural differences and behavioral patterns often cause difficulties in the personnel relations between members of the operation and maintenance staff. In order to select personnel with compatible cultural and behavioral backgrounds, an applicant test program shall be prepared. The relevant tests shall be utilized during personnel recruitment and hiring.

Difficulties in the personnel relationship between the staff members shall be detected on the basis of personnel records, and shall be solved by meetings with the concerned employees.

The benefits and everyday needs of the employees shall be considered by maintaining optimum labor relations, public relations and supply of medical, social and clerical services.

D.2.3 Legal and Financial Aspects

D.2.3.1 General

The Contractor shall verify and consider all legal aspects concerning staff engagement, land and property acquisition and disposal, disputes and claims with regard to the national and local conditions of law.

During Operation Service Period, all capital investment, costs, payrolls and taxes shall be accounted, recorded and paid by the Contractor.

The tasks of the Contractor will also include the general budgeting of Operation Service Period, the utilization of proper audit functions and the administration and payment of assurances.

The Contractor shall be responsible for the payment of all electricity, water and other services utility costs in connection with the Operation and Maintenance of the Works as well as any charges for the disposal of sludge and other residuals.

D.2.3.2 Damage

The Contractor shall be responsible for any damage to the Works caused by his operation and maintenance services. The Contractor shall eliminate the damage without undue delay and without additional cost to the Employer.

The Contractor shall be responsible for any damage to public properties caused by his operation and maintenance services. The damage shall be searched, identified and repaired on the expense of the Contractor, even if the Employer will receive a relevant invoice from the concerned parties.

D.2.4 Safety and Security

The Contractor shall submit a Health and Safety Plan as required by Lebanon Legislation.

D.2.4.1 Safety

The Contractor shall provide a safety specialist being responsible for the preparation, implementation and maintenance of a comprehensive safety program, which shall be periodically evaluated during Operation Service Period and be approved by the Employer's Representative. The specialist shall develop the safety and health policies, standards and procedures.

The responsibility of the safety specialist includes performing safety training and conducting safety inspections, sessions and practice. He will also be responsible for the investigation of accidents.

A safety committee shall be formed and regular safety meetings shall be organized.

All safety equipment and tools shall be provided and maintained by the Contractor.

D.2.4.2 Fire Protection

The safety specialist shall prepare, implement and maintain a comprehensive fire protection and prevention program, which shall be approved by the Employer's Representative.

The safety specialist will also be responsible for the inspection and maintenance of the fixed and portable fire protection equipment and for the investigation of fire incidents.

During Operation Service Period, the safety specialist shall develop and implement a project emergency action plan and fire hazard inspection procedure.

D.2.4.3 Security

In order to protect property, materials and facilities against unauthorized entry and trespass, pilferage and theft, destruction, damage, sabotage, embezzlement, fraud and other dishonest, illegal or criminal acts during the Operation Service Period, a security program shall be prepared, implemented and maintained. The Employer's Representative shall approve the security program.

D.2.5 Reporting

The Contractor shall submit monthly and annual reports including any important details concerning performance, staffing, training and Operation and Maintenance of the Works. After approval by the Employer's Representative, the reports shall be used as a guide for regulation, adjustment and modification of the plant facilities. The reports shall continuously record and demonstrate the performance of staffing, training and Operation and Maintenance. The number of copies of each monthly report shall be six (6), the number of the annual reports shall be fifteen (15). The layout of the reports and other general requirements shall be discussed with the Employer's Representative and arranged to his satisfaction.

The shift leaders in charge of operation during the 24-hour day shall prepare a daily machine journal. The journal shall be a record of all the readings of flow rates, counter readings, pressure values, temperatures, odors, etc. for all facilities and equipment of the treatment plant. A file shall be maintained on site for storage of hardcopies from supervisory control panel printouts showing the listed parameters. In addition, all characteristic operation data of any major item of the treatment plant and all remarks and comments of the shift leaders concerning abnormal readings, overloads, stoppage, outages and other operation events shall be recorded.

Monthly laboratory reports shall be prepared presenting the results of the records of laboratory tests and continuous quality control measurements.

The monthly reports shall be prepared including, but not being limited to:

- monthly influent flow rate curves and tables showing daily maximum, average and minimum inflow values,
- quantities of sludge and other residuals and record of delivery to disposal site,
- laboratory average daily, weekly and monthly results tabulated with maximum and minimum values,
- diagrams showing the performance of the Works,
- calculation of monthly penalties for non-compliance with the attainable criteria for the set parameters,
- daily consumption figures of electricity and chemicals,
- service hours of main machinery and equipment,
- times, duration, reason and remedying of emergency operation and outages,
- other data requested or events of significant importance,
- statistics of staff members and labor utilization,
- information on major equipment repair, overhaul and other maintenance works,
- spare parts used and mobile equipment,
- monthly expenditures.

Annual reports shall be prepared including, but not be limited to:

- monthly average influent flow rates with maximum and minimum values and annual value,
- monthly and annual quantities of sludge and other residuals and record of delivery to disposal site,
- monthly average quality of influent, effluent, sludge and odor emission with maximum and minimum values as well as other data as temperatures, etc.,
- summary of monthly penalties for non-compliance with the attainable criteria for BOD5, dry solids content of sludge cake and H2S emission,
- monthly and annual electricity and chemical consumption figures,
- service hours of main machinery and equipment,
- monthly and annual staff and labor utilization,
- times, duration, reason and remedying of emergency operation and outages,
- information on major equipment repair, overhaul and other maintenance works,
- spare parts used and a list of remaining spare parts,
- monthly and annual expenditures.

D.2.6 Access to Facilities

The Employer shall have the right to bring visitors to the treatment plant. The visitors shall be received by the Employer and the Contractor shall not be in charge of such visits. Visitors shall only have access to the meeting room facilities and the special visitors circuit provided in the plant.

The Employer shall give notice at least 48 hours in advance for visits.

The Contractor shall provide 2 offices to the Employer.

D.3 OPERATION

D.3.1 Planning and Management

The Contractor shall entrust adequately experienced key staff with the responsibility of operating the wastewater treatment plant.

The key staff shall plan, establish and administer the organization of the operation of the plant.

D.3.2 Provision of Electricity, Chemicals, Vehicles and Spare Parts

D.3.2.1 Provision of Electricity, Chemicals, Lubricants and Consumables

During the entire Operation Service Period, the Contractor shall provide the necessary supplies of electricity, chemicals, lubricants, fuel and consumables sufficient to continuously operate the Works.

Lubricants shall be supplied in accordance with the recommendations of the various equipment and Plant manufacturers.

The Contractor shall limit the various types of lubricants by consolidating these, with the manufacturer's approval, into the least number.

The Contractor shall provide the Employer's Representative with three (3) copies of a list showing the proper lubricants (after consolidation) for each item of equipment and Plant with a schedule giving the estimated frequency and quantity of lubrication required. This will not relieve the Contractor from supplying this information within the Operation and Maintenance Manuals as well.

At the end of the Operation Service Period, the Contractor shall provide to the Employer adequate supplies of chemicals, lubricants, fuel and consumables sufficient to continuously operate the Works. Such supplies shall cover one (1) month supply of locally available materials and six (6) months' supply of materials not locally available.

D.3.2.2 Provision of Tools and Appliances

The Contractor shall make use the tools and appliances supplied under the Contract pursuant to the Employer's Requirements. In addition, the Contractor shall provide two complete sets of such tools and appliances not supplied before, but found to be necessary for proper Operation and Maintenance of the Works.

At the end of the Operation Service Period, the Contractor shall hand over to the Employer two complete sets of all tools and appliances. The Contractor shall replace tools and appliances which are not in a serviceable condition or which have been lost.

D.3.2.3 Provision of Spare Parts

The Contractor shall make use of the spare parts supplied under the Contract pursuant to the Employer's Requirements. In addition, the Contractor shall provide at his own expense such spare parts not supplied before, but found to be necessary for proper Operation and Maintenance of the Works.

At the end of the Operation Service Period, the Contractor shall hand over to the Employer adequate supplies of spare parts sufficient to operate and maintain the Works for a further period being equal to (5) years after the end of the operation period carried out by the Contractor. The requirement for such spare parts will be based on a comparison of spare parts used during the actual Operation Service Period carried out by the Contractor and on the manufacturers' written confirmation of recommended spare parts, and will have to be agreed with and approved by the Employer's Representative.

D.3.2.4 Disposal of Sludge and Residuals

The Contractor shall arrange for the disposal of any screenings, grit, sand, other wastes, debris and residuals removed from the wastewater or generated at the treatment plant to a landfill located not more than 100 km away from the Site.

Dewatered sludge shall be transported to a landfill site located not more than 100 km from the WWTP site.

All cost in connection with the disposal of residuals and transportation of sludge shall be borne by the Contractor except for landfill damping fees (if any), the unit price of the landfill shall be determined later in agreement with CDR and the contractor.

D.3.3 Penalties for Non-Compliance

Following the completion of the Performance Tests Periods, the attainable criteria with regard to effluent standard, characteristics of sludge and odor emissions will have been determined, which will be assumed to be either the guaranteed performances or the average of the results obtained from the two Performance Tests Periods whichever is applicable (i.e. if the performance test were failed and damages have been paid, the results actually obtained will apply).

The Contractor shall be responsible for taking whatever steps are necessary to maintain these attainable criteria during the Operation of the Works.

The Contractor shall carry out the composite and continuous sampling and testing as described in Sub-Clause 5.2 below, and any other tests as necessary to fully control and monitor the performance of the wastewater treatment plant.

Penalties for non-compliance with regard to effluent standards will apply. The amount of these penalties is defined in the Particular Conditions – Special Provisions.

D.3.4 Emergency Conditions

The Contractor shall establish requirements for dealing with potentially hazardous conditions. All possible situations of emergency shall be scheduled within an emergency plan. Herein, the required services, additional required structures, equipment, staff and other resources shall be planned and recorded for the possible situations of emergency. The emergency action plan shall be submitted for approval to the Employer's Representative.

Every effort shall be made to ensure that any emergency situation at the treatment shall be limited to the shortest possible period to minimize any negative effects on the environment.

Any necessary shutdown of the plant for operational adjustments shall be restricted to the possibly shortest period with minimum flow at the inlet works and shall be approved by the Employer's Representative.

D.4 MAINTENANCE

D.4.1 General

Administrative maintenance policies shall be prepared and implemented by the Contractor, based on the developed maintenance program. The policies shall be approved by the Employer's Representative and shall include, but not be limited to:

- preventive maintenance,
- overhauls and half-overhauls plan,
- outages and unexpected repair works plan.

A basic maintenance management system shall be implemented after approval by the Employer's Representative. It shall include, but not be limited to:

- planning and scheduling,
- maintenance personnel,
- maintenance instructions,

- inventory control of items,
- equipment records,
- forms for costs and budgets.

The Contractor shall periodically carry out maintenance. It shall include, but not be limited to the provision of all required spare parts, material and personnel.

All items of equipment shall be inspected and maintained in accordance with the manufacturer's specifications and to the local conditions. Replacements, repairs and painting shall be carried out immediately and when necessary. Maintenance records showing all maintenance work carried out on each item of equipment shall be updated daily and shall be made available at any time for examination by the Employer's Representative. The installed equipment shall be checked and serviced daily.

The operating conditions of any instrument shall be maintained by function checks and services. Calibration shall be checked and corrected whenever necessary. After submission of the calibration data for approval, the instruments shall be calibrated as required and directed by the Employer's Representative.

Water retaining structures shall be cleaned regularly and freed from all clinging matter, which should be disposed at approved sites. Maintenance services shall include, but not be limited to the repair of surfaces and cracks, correction and/or repair of irregularities and defects at construction and expansion joints, corrective measures ensuring the water tightness and painting.

The buildings, HVAC, electrical and sanitary installations shall be kept clean and continuously maintained in a proper and orderly manner. All interior and exterior structures, structural elements, equipment, installations, infrastructural elements and others shall be maintained, repaired, painted and replaced if necessary and/or as directed by the Employer's Representative.

The maintenance of site works shall include, but not be limited to the repair, painting and the replacement of defective items for traffic areas, pipes and fittings (including protection), cables, channels, roads, lighting poles and fences and shall also include the maintenance of lawn areas, plants, shrubs, bushes and trees.

D.4.2 Management

The management of maintenance shall include, but not be limited to:

- implementation and operation of a separate maintenance budget system comparing the budget with the general budget of Operation and Maintenance,
- planning and controlling the work of subcontractors.
- establishing of requirements for equipment manuals, for each item of equipment,
- setting out procedures for installation and commissioning, instructions for Operation and Maintenance and listings of component parts.

D.4.3 Planning and Scheduling

The performance of maintenance shall be administered using a maintenance work package system in which the job priorities, the work assignment and the available personnel are listed. The required daily work shall be scheduled in charts by the hour or more detailed.

The maintenance work package system shall consider the manufacturers' maintenance manuals and also conditions like topography, climate and operation of the wastewater treatment plant.

The maintenance work package system shall include a chart for periodic maintenance of any equipment and Plant on Site. The chart of every equipment and Plant shall indicate any necessary step of preventive maintenance.

The maintenance work package system shall be submitted to the Employer's Representative for approval.

D.4.4 Maintenance Personnel

Only highly skilled and trained personnel shall be assigned to perform inspections, repairs and preventive maintenance tasks. Specific skills are required for the maintenance of mechanical, electrical and instrumentation machinery and equipment.

D.4.5 Maintenance Instructions

At an agreed central location, all manufacturers' maintenance manuals and other information shall be filed for each item of equipment.

The recorded data shall be well organized and documented together with the relevant general arrangement drawings in order to enable ready availability.

A manual describing the preventive maintenance of the equipment and Plant shall be prepared and approved by the Employer's Representative.

All the information mentioned above shall be available to the maintenance staff.

D.4.6 Inventory Control of Items

A central storeroom for spare parts, equipment and supplies shall be maintained. All parts shall be assigned with item identification codes, each of them possibly being an extension of the design and construction documents.

A computerized system shall be implemented using the item identification code to record all necessary information of any item, to place the items in the storeroom and to re-order the items in case of requirement. This system shall keep a record of the quantity of each item remaining in stock, shall allow a direct comparison with the recommended stock level, as well as indicating the replacement lead-time.

D.4.7 Equipment Records

The performance and the future requirements of maintenance shall be recorded daily and updated in the equipment records. All maintenance of equipment, identification of occurred problems and action taken to avoid failure shall be recorded. The records shall be made available at any time for examination by the Employer's Representative.

D.4.8 Work Control and Outage Planning

Work control shall be established by preparing and implementing procedures of corrective and protective maintenance, of tool control and of spare parts issues.

Outages of maintenance shall be bridged or repaired as soon as possible so as to minimize negative effects on the environment. Therefore, the Contractor shall use a standard procedure like the critical plan method (CPM) to sufficiently schedule for maintenance outages.

Resource planning shall be carried out in order to find out the requirements for special materials, special tools and/or special equipment for bridging or repairing any outage as soon as possible.

D.5 TECHNICAL SERVICES

D.5.1 Plant Chemistry

The Contractor shall develop and maintain a chemical treatment program to minimize corrosion, extend system life and maintain efficiency of the wastewater treatment plant.

The project systems shall be reviewed and recommended in relation to the chemical treatment program. Required improvements of the systems shall be carried out, after approval by the Employer's Representative.

The Contractor shall provide the staff necessary for implementation of the chemical treatment program.

D.5.2 Monitoring

The measured values and results shall be recorded daily and shall be presented in weekly reports and in the monthly and annual reports being submitted to the Employer's Representative.

D.5.2.1 Wastewater Treatment

5.2.1.1 Flowrate Measurements

All measurement instruments shall be checked and rated once a year and a rating certificate provided.

Continuous discharge measurements, with graphic recordings, shall be performed at the following points:

- At the plant headworks: metering of effluent inflow.
- Metering of treated water prior to discharge.
- By-pass if any
- Return water from the internal sewerage network

The sludge recirculation flow must be checked continuously, either directly by using the metering instruments provided for this purpose, or indirectly by operating the pumps.

5.2.1.2 Quality of Treatment

A laboratory will be created at the plant. The scope of the laboratory is to undertake the necessary chemical, physical and microbiological tests required for the performance monitoring of the WWTP.

The performance monitoring tests, as shown hereafter, will be conducted in laboratory by the Employer.

The Contractor will be responsible to carry out all the tests necessary for the daily operation of the plant. The Contractor will use this laboratory to perform any tests he may deem necessary for the daily operation of the plant.

5.2.1.2.1 Wastewater Parameters to be Monitored

The monitoring of the wastewater treatment quality will be carried out by the Contractor. Analyses will be carried out by an independent laboratory two times per year in order to validate the results and methods used. The costs of these independent tests will be borne by the Contractor.

The temperature of effluent entering the treatment plant will be checked.

Twenty-four-hour flow-proportional composite samples will be collected each day on untreated wastewater at the inlet and on treated effluent.

Each sample shall be analyzed for the following parameters:

- COD (every day),
- BOD5 (every day),
- TKN (1 day / month), TP (for info only - 1 day/month),
- SS (every day),
- pH (every day),
- conductivity (every day),
- turbidity (every day)
- Fecal coliforms (1 day / month),
- Intestinal worms (1 day / month).

5.2.1.3 Checking The Operation of Certain Structures

Various measurements and checks are performed to assess the operation of individual structures.

The test protocol shall be proposed by the Contractor and approved by the Employer's Representative. The Contractor shall provide intermediate inspection parameters for assessing the proper operation of the structures, for example localized inflow/outflow samples, sludge characteristics, etc.

The test protocol shall include the following points in particular:

a) Grease and oil traps

Every three months, two localized samples are taken upstream and downstream of the structure, and the quantity of hexane-extractable material (HEM) analyzed.

Part of the upstream sample is subjected to dissolved air flotation in the laboratory, lasting at least 2 hours.

The elimination rate obtained in the laboratory is taken as a standard. The efficiency observed in the field is expressed as a percentage of the laboratory rate (the field "efficiency" may even be above 100%).

b) Preliminary treatment waste

A sample of the following waste is taken each week:

- Screening rejects following compaction.
- Grit after washing.

The dry matter and volatile matter content of each sample is analyzed.

The quantities produced are measured each day and expressed in m3 and kg of dry matter.

c) Reagent consumption

The consumption level must be measured daily on any treatment process involving the addition of reagents.

d) Primary Clarifier

- Daily measurement of TSS
- Continuous recording of primary sludge pumping

e) Biological reactor

- Daily measurements of MLSS levels in the bioreactor
- Continuous dissolved oxygen level measurement.
- Daily measurement of NO3-
- Daily measurement of NH4+

D.5.2.2 Sludge Treatment

The production of primary, biological shall be measured continuously (where applicable).

The quantities of sludge must be noted at each stage (thickening, dewatering, lime addition) and if necessary for each type of sludge.

The quantities of reagents consumed must be noted.

Localized samples of all types of drippings (overflow, filtrates, centrifugates, etc.) must be taken two times per month.

Sludge analysis shall be carried out every week. The analyses shall be performed on mean samples obtained by mixing six grab samples taken over a 24-hour period, and shall concern the following parameters:

- fresh liquid primary, biological sludges: SS, VSS, dryness, pH, redox,
- thickened primary, biological sludges: SS, VSS, dryness, pH, redox,
- dewatered sludges: SS, VSS, dryness, pH,

- lime treated sludges: dryness, pH, lime content
- for each type of dripping: SS, BOD5.

D.5.2.3 Air Extraction and Odor Treatment

Odor treatment tests shall be carried out on site two times per year.

At least two series of air samples shall be taken at each test occasion, on 2 separate days.

The samples shall be taken during a period when all the installations, in particular those involved in sludge treatment, are in operation.

All air distribution and removal devices inside the premises shall be set correctly. All openings other than those intended to admit fresh air must be closed.

The sampling techniques shall comply with standard NF X 43.104.

Each series of samples shall cover the following points:

- Odor treatment

Samples of polluted air entering the deodorization system and of treated air leaving the treatment system shall be taken.

The analyses performed on the samples of air entering and leaving the deodorization system shall concern the specific gases that are to be treated, as defined in the Performance Specifications.

The elimination rate shall be calculated for each gas that is to be treated.

- Odor level at the edge of the property

Samples of air shall be taken at the edge of the property. The sampling points shall be chosen in agreement with the Employer's Representative. The analyses shall concern the gases for which maximum thresholds are defined the Performance Specifications.

D.5.2.4 Checking of General Operation

5.2.4.1 Energy Consumption

Active and reactive energy consumption shall be measured each day for the plant as a whole and for each of the main components. Voltage, Intensity and CosΦ shall be carried out in order to check the power of each equipment and for the whole installation.

5.2.4.2 Drippings and Septage

The total volume of drippings and added septage shall be recorded each day. The corresponding pollutant loads must be measured each day.

5.2.4.3 Other Points to be Noted

- Consumption of all reagents.
- Working time of the main items of equipment: lifting, aeration, recirculation, air extraction, thickening and centrifugation.
- Ventilation rate on each line and operating pressure.
- Measurements of power consumption by equipment: compressor, stirrers, centrifuges, etc.

D.5.2.5 Noise

Noise levels shall be measured two times per year. Noise measurements shall be carried out shall during a period when all the installations, in particular those involved in sludge treatment, are in operation.

- At the edge of the property

During the tests, an overall measurement of the noise emitted by the installation shall be carried out at the edge of the property. The measurement shall be made by an organization approved by the Employer and in accordance with the conditions set out in standard NF S 31.010.

The measurement point shall be chosen in agreement with the Employer.

The measurement shall be carried out for a period of 24 hours, during which the installation shall be in normal operation, in conditions that are as close as possible to nominal working conditions.

- Within the premises (at the plant)

The appropriate measurements shall be performed to ensure that the arrangements made by the Contractor comply with regulations concerning the safety of staff and with the guarantees provided by the Contractor.

D.5.3 Data Filing and Processing

Sufficient hardware and software shall be supplied, installed and operated in order to enable the following data filing and processing operations. Sufficient trained staff shall be provided to ensure that this system runs efficiently.

- all kind of process control measures,
- inventory control concerning supply and removal items,
- all kind of management,
- preparation of reports in English languages,
- record keeping and operation,
- maintenance of equipment and laboratory data,
- additional programs as directed by the Employer's Representative.

The hardware and software configuration shall comply with the actual required minimum standards for running the latest version MS Windows. At the end of the Operation Service Period, the hardware and software shall be handed over to the Employer.

In order to achieve a proper functioning control of process performance, an interdisciplinary reporting and data filing system shall be provided and operated, combining the fields of Operation and Maintenance like expenditure, personnel, operations performance, maintenance performance and laboratory activities.

Changes in the computer systems shall be documented. Proposed computer system modifications shall be developed or reviewed. The realization of modifications and repairs shall be coordinated by the Contractor.

D.5.4 Quality Control

The Contractor shall develop a quality assurance program resulting in a quality control manual, which shall agree with the Standard EN ISO 9001.

A quality control management system shall be developed and maintained, based on the prepared quality control manual. All employed staff shall be trained in the application of the quality control management system.

All programs and systems prepared for Operation and Maintenance as well as for Staff Training shall be integrated in the quality control management system.

The quality control management system shall be approved and finally certified by a commonly accepted certification agency.

D.6 TRAINING

D.6.1 General

On-Site Training of the Recipient's staff to manage, operate and maintain the project shall be included in the tender.

The objective of the training is to provide selected staff members of the Recipient with the necessary knowledge of technology, operation and maintenance of all equipment, installations and work included in the project, which will ensure a sound and stable operation and maintenance of the project components carried out under the contract.

During the last year of the Operation Service Period, the Contractor shall provide on-site training of the Employer's staff in managing, operating and maintaining the Works on the basis of a structured program submitted at least two (2) months before the start of the training period for the approval of the Employer's Representative.

The Contractor will be required to provide practical instructions to the Employer's staff during this period to ensure that by the end of this period the staff will be considered by the Employer's Representative to be capable of managing, operating and maintaining the Works to the highest internationally accepted standards without additional supervision.

Training shall be based on all the procedures detailed in the Operation, Maintenance and Safety Manuals including, but not limited to managing, operating, controlling and performance monitoring of the treatment process, data filing and processing, reporting, assembly, dismantling and maintenance of equipment and Plant as well as fault finding, without affecting the normal Operation and Maintenance. Particular emphasis shall be laid on safety precautions during Operation and Maintenance.

The training shall in general consist of familiarization with the operational aspects of the systems as a whole, followed by familiarization with specific items of equipment.

The training shall be based on the actual plant and the implementation of operation and maintenance schedules outlined in operation and maintenance manuals provided by the Contractor.

The training shall also be directed towards the specific requirements of the trainee, as the instruction and familiarization of the various personnel involved will vary with respect to their operational capacity, as the personnel will require different aspects to be emphasized.

All training shall be successfully completed and demonstrated before termination of Operation Service Period can take place. If in respect of progress of works and the daily operation of the plant and systems, it is required that any systems or equipment has to be put into use by the Recipient before Taking Over, it is the Contractor's responsibility that all necessary instructions and training have been given to the Employer's personnel, for full understanding of the technology and operation, prior to commencement of the Recipient's utilization of such systems or equipment.

The Contractor shall employ a separate representative for the training procedure. This representative shall have an adequate knowledge of the Greek and of the English language. The Contractor shall make available to him all procedural documents produced in accordance with the Employer's Requirements.

The representative and the trainees shall be allowed the unhindered access at any time to any part of the Works.

The liability for the entire Works during training remains with the Contractor, independently of who may be responsible for any fault or damage.

The Recipient will cover all costs in connection with wages and expenses of the Recipient's personnel assigned for training and instruction.

The total allowance to cover the Contractor's expenses in connection with training shall be included in the tender.

D.6.2 Training Program

The training program shall include, but need not be limited to the following:

- Organizational structure of the personnel required for management, Operation and Maintenance of each component of the Works.
- Manpower requirements, by skills and trades, necessary for the management, Operation and Maintenance of each component of the Works.
- Detailed description of each element of the training program, which will show how the necessary skills shall be imparted to the personnel, assigned by the Employer.
- Identification of the minimum educational levels or standards of technical skill which must have been obtained for each position by the assigned personnel, which levels and standards should be readily available in Cyprus.
- CVs of the proposed Instructors, including qualification and education.

D.6.3 Execution of Training

To ensure that adequate training is given, the training personnel from the Contractor shall carry out each and every Operation and Maintenance activity identified in the Operation, Maintenance and Safety Manuals and shall train the Employer's personnel to carry out these activities even if they are not required during the actual operation of the Works.

The Contractor shall pay particular attention to safety training for all assigned personnel. Safety training shall not be limited to personal safety, but shall include detailed actions to be taken by all staff in emergency situations and the use of all safety equipment. The Contractor shall be responsible for establishing procedural links with the appropriate emergency services.

The Contractor shall provide all necessary facilities for training including didactic equipment, simulators video, slide and overhead projection equipment. The necessary specialist buildings or rooms for training shall be provided as part of the Permanent Works. All training equipment shall become the property of the Employer at the end of the Training Period.

Training shall be carried out in the English language. However, the Contractor shall provide a sufficient number of Arabic / English interpreters to overcome any difficulties arising due the assigned personnel not being completely fluent in the required language.

D.6.4 Technical Content

D.6.4.1 Training for Operation of the WWTP

The Contractor’s training shall include 2 weeks of theoretical training and 2 weeks of on-site training for 6 operators selected by the Employer. It is anticipated that the 6 operators are process, mechanical and electrical staff, 2 of each. The plant, which shall be in operation, shall be selected by the Contractor and agreed upon by the Employer.

D.6.4.2 Training on the Scada System

The Contractor’s training shall include 2 weeks of theoretical training and 2 weeks of on-site training for 6 operators selected by the Employer.

A. System Operators

The Contractor shall provide for the number of attendees as specified here-above.

This purpose-designed course is to be held at the Centralized Technical Management on site. Training must be provided in advance of commissioning to:

- Enable the Recipient’s user staff to participate in the full process commissioning of the system,
- Optimal operation of the Plant, including both sewage and sludge lines,

- Safely operate the plant and maintain the SCADA system.

B. Course Contents

This course shall be designed to familiarize the participants with the general running of the standard operating system and the SCADA package to include but not limited to:

- Loading and starting up the Operating System,
- System Operators interface,
- Operator control of program/task execution,
- Operator control of disc files,
- File transfer tasks – archiving, retrieval,
- Operator response to system failure, on-line/off-line diagnostics, transfer of control between the computers synchronization of the system database,
- SCADA system interrogation facilities – alarm lists, log printouts select mimic and trend display etc.,
- Alarm acknowledges accept/delete,
- Control actions, e.g. start pump, close valve,
- All functions associated with each access level of the SCADA system.

C. System Supervisors Personnel

The Contractor shall provide a five-day course for the number of attendees as specified here-above.

To be held at the Works Control Centre prior to the systems hand-over and shall consist of all of the above tasks plus:

- Basic systems design overview,
- The use of computers to perform diagnostics and to tune other parts of the system,
- Changing passwords and access control,
- Sequence verification,
- Preventive maintenance.

D. System Developers/Programmers/Engineers

The Contractor shall provide 1 no. five day course with the number of attendees as specified here-above.

This course shall be designed to cover all configuration and advanced facilities of the SCADA package. To include, but not be limited to:

- The system database structure,
- System database building/configuration,
- Mimic building,
- Applications program interface to the system database,
- Management information system interface,
- Downtime loading of control programs/sequences to PLCs,
- Advanced operating features.

D.6.5 Contractor's Personnel

The Contractor shall provide training personnel for each of the positions required for management, Operation and Maintenance as identified in the training program. All Instructors shall be qualified personnel with at least 15 years of experience in their training field; their CVs will be submitted to the agreement of the Employer in the Training Program.

The duties of each of the training personnel shall be to manage, operate and maintain that element or those elements of the Works appropriate to his position, and to train the Employer's assigned staff members for that particular position. The emphasis shall be on “hands-on” training.

In addition to his normal training personnel, the Contractor shall also provide specialist trainers who shall be responsible for formal classroom, laboratory or workshop training.

D.6.6 Training Test Period

The last 30 (thirty) days of the Training Period shall be considered as the Training Test Period. During this period, the Works are to be entirely managed, operated and maintained by the Employer’s assigned personnel. The Contractor shall remain, nevertheless, fully responsible for the successful Operation and Maintenance and his training personnel shall remain on site to act in an advisory capacity if needed.

If, during the Training Test Period, any section of the Works fails to achieve the required performance standards or any fault cannot be located or rectified, the training personnel is required to assume "hands-on" operational activities.

If the Employer's Representative considers that the Works are not being properly managed, operated or maintained, the Contractor shall immediately provide additional training as necessary. Once this additional training has been successfully completed, the Contractor shall seek the Employer's Representative's approval for a repeat of the Training Test Period of 30 days for that section of the Works. Training Test Periods shall be repeated until the Employer's Representative is satisfied that the assigned personnel is successfully managing, operating and maintaining the Works.

No additional payment will be made to the Contractor for the repetition of a Training Test Period as described above, nor will the Contractor have the right to claim any payment in connection with Operation and Maintenance for the repetition of any Training Test Period.

D.7 FINAL TESTS

Prior to the end of the Operation Service Period, the Works will be finally tested for their performance and the condition of the Works will be checked.

Provided the Works achieve the performance as guaranteed under the Contract (or the attainable performance if damages have been paid for shortfall of performance), and maintenance with all necessary repairs, replacements etc. as well as staff training has been carried out to the satisfaction of the Employer's Representative, and the spare parts, chemicals, lubricants and consumables as described further above have been provided by the Contractor, and the Contractor has completed all his other obligations under the Contract with regard to O&M Period, the Completion Certificate for Operation Service Period will be issued by the Employer's Representative, and the Employer will continue to operate and maintain the Works.

SECTION VII – EMPLOYER'S REQUIREMENTS

PART E: TECHNICAL SPECIFICATIONS: CIVIL AND BUILDING WORKS

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SECTION 01001
DESIGN CRITERIA FOR CIVIL ENGINEERING

1 STANDARDS

A. Lebanese regulations regarding the construction in the vicinity of Airports.

- Regulations of Lebanese Civil Aviation Authority
- Any other regulations of Beirut Airport Authorities.

B. Lebanese standards

All Lebanese standards shall be respected and have priority over the other standards listed below.

C. European standard

The structure is designed according to the most recent European Standards:

- EN 1990 – Eurocode 0 – Basis of structural design: All parts of Eurocode 0,
- EN 1991 – Eurocode 1 – Actions on structures: All parts of Eurocode 1,
- EN 1992 – Eurocode 2 – Design of concrete structures: All parts of Eurocode 2,
- EN 1993 – Eurocode 3 – Design of steel structures: All parts of Eurocode 3,
- EN 1994 – Eurocode 4 – Design of composite steel and concrete structures: All parts of Eurocode 4,
- EN 1995 – Eurocode 5 – Design of timber structures: All parts of Eurocode 5,
- EN 1996 – Eurocode 6 – Design of masonry structures: All parts of Eurocode 6,
- EN 1997 – Eurocode 7 – Geotechnical design: All parts of Eurocode 7,
- EN 1998 – Eurocode 8 – Design of structures for earthquake resistance: All parts of Eurocode 8,
- EN 1999 – Eurocode 9 – Design of aluminum structures: All parts of Eurocode 9,

D. French standards

- Fascicule 74,

2 GENERAL

All criteria exposed bellow is defined in the above-mentioned standards.

1. Class of consequences of structure: CC3
2. Service life of the structures: 50 years
3. Class of watertightness of liquid retaining structures: Class 1
4. Class of exposure:
   a) XA3, for concrete surfaces exposed to sulphides,
   b) XA2, for concrete surfaces exposed to underground water, wastewater and sludge,
   c) XS3 Where concrete containing reinforcement or other embedded metal is subject to contact with chlorides from sea water or air carrying salt originating from sea water,

d) XC4 for other concrete surfaces.

5. Thermal effects:

   a) The thermal difference between internal and external faces of reservoirs wall is taken to 20°C for thermal moment's calculation.

   b) For all structures with a length superior to 30 m and without movement joints, thermal dilatation and shrinkage shall be considered in the calculation.

6. Crack opening criteria:

   a) For the concrete elements retaining liquid, crack opening depends of the class of watertightness and is defined in "EN 1992-3". If the conditions in (112) and (113) of "EN 1992-3" are not fulfilled, the crack opening wk1 for both faces shall be limited to 0.15mm (or 0.10mm for XS3) and the maximal tensile stress in the homogenized section to f_{ctm}, under characteristic load combination.

   b) For concrete elements not retaining liquid, the maximum crack width is fixed at 0,20mm (or 0.15mm for XS3).

   c) Finally, in all cases, the maximum stress in steel at Serviceability Limit State shall be 200 MPa.

7. All dispositions (including structural total and differential settlements according to European Committee for Standardization-1994a and 1994b) shall be taken into account concerning the stability and the watertightness of pipes embedded into concrete elements, the pipes may need to be provided with angular couplers and axial expansion joints.

8. Levels indicated on drawings are considered after settlement.

   a) Maximal absolute settlement: ..... 20 mm

   b) Maximal relative settlement: ..... 1 mm / meter

3 MATERIALS

A. Concrete

The concrete of the structures is classed as graded C35/45, according to EN 1992-1, thus:

- f_{ck} ..... = 35 MPa
- f_{ctm} ..... = 3.2 MPa
- E_{cm} ..... = 34 GPa

Other characteristics are:

- Unit weight: ..... 25 kN/m³ when unfavorable
  ..... 24 kN/m³ when favorable
- thermal expansion coefficient ..... 10-5 °K-1
- Average shrinkage strain ..... ε_{cs} = 2.10-4

B. Rebars

- Ductility class C, according to EN 1992-1 Appendix C
- f_{yk} ..... = 500 MPa
- k (f_t/f_y) ..... ≥ 1.15 and <1.35
- εuk ..... ≥ 8 %

- Es .....= 200 GPa
- Cover: .....According to EN 1992-1, with a minimum of 60 mm for XA2 exposed concrete (or a minimum 65mm for XS3).

C. Steel used for steel constructions

According to the section 05000 - Structural Steel Construction.

4 ACTIONS

A. Wind

According to EN 1991, with data taken from section VII – A. General specifications.

B. Earth

Unit weight of soils (such as compacted Manmade Fill Type – S2 and/or Engineering Fill 0/406.4mm) and active pressure coefficients shall be adopted from geotechnical investigations report included with Tender documents. However, these values shall be validated / updated upon completion of the further / complementary geotechnical investigations to be executed by the Contractor.

C. Hydrostatic pressure

Unit weight of raw water and drinking water is 10 kN/m³

Unit weight of wastewater and sludge is 11 kN/m³

Design shall consider every possibility of liquid levels in structures. Particularly, some intermediate walls can be in the case with full level liquid on one side and no liquid on the other.

Hydrostatic pressure shall be considered with the following factors: $\psi 0 = \psi 1 = \psi 2 = 1$

D. Snow

According to EN 1991, with data taken from section VII – A. General specifications.

E. Seism

According to EN 1998, with data taken from VII – A. General specifications and the following precisions:

- Expected peak ground acceleration (PGA) of 0.30g for a 50 years' time span as proposed in the geotechnical investigation report of October 2024 (Appendix D),
- Importance class: III,
- Soil class as per the EN 1998: D (stiff soil) considering the geotechnical investigations and deep dynamic compaction.

F. Loads during works

Load on earth fill is either 12 kN /m² or the load generated by a crane depending on Contractor methods. The most unfavorable case shall be considered for calculation.

G. Live loads

According to EN 1991, with the following precisions:

- Raft, industrial slab and slab receiving public: .....5 kN/m²
- Inaccessible terrace (except for maintenance): .....1,5 kN/m²
- Accessible terrace: .....2,5 kN/m²
- Heavy load roads: .....AASHTO H-20 truck

- Live loads around structures: ..... 12 kN/m²

H. Fire

- Minimum: ..... ½ h firewall
- Normal risk rooms: ..... 1 h firewall
- High risk rooms: ..... 2 h firewall

Transformer rooms, electric rooms and chemical rooms are considered high risk.

5 CALCULATION

Calculation shall be made according to Eurocode methods (or as directed by the Engineer), considering both STR and GEO ultimate limit states. For GEO, the approach 2 defined in EN 1997-1 shall be used.

Both Ultimate Limit Sate and Serviceability Limit Sate shall be calculated, respecting all criteria given in this section

A. Geotechnical assumptions

Preliminary geotechnical assumptions shall come from the geotechnical report given with Tender documents. However, these assumptions shall be validated / updated upon completion of the further / complementary geotechnical investigations to be executed by the Contractor.

B. Stability against uplift pressure

Stability of structures against uplift pressure shall be verified with UPL Ultimate Limit State.

Unless otherwise specified, calculation of structures and buried pipes against uplift pressure shall be done considering the highest water table level mentioned in the geotechnical report, the high-tide shall also be taken into consideration.

C. Stability of excavations against buoyancy

Stability against buoyancy shall be verified with HYD Ultimate limit state.

D. Combinations of action to verify

The combinations of action to verify, both for Serviceability Limit State, and for Ultimate limit states STR, GEO, UPL and HYD, are given in EN 1990 and EN 1997.

SECTION 01010
CORROSION PROTECTION

1 GENERAL

1.1 Work Included

This section of specifications covers the corrosion protection of all equipment to be supplied, or existing to be rehabilitated, unless different requirements are specified in the subsequent sections.

1.2 Related Work

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section VII – B. Performance requirements;

1.3 System Description and Characteristics

1.3.1 General

Non-structural metal elements, such as handrails, stairs, ladders, fittings, etc. shall be made of stainless steel, aluminum or glass fiber reinforced polyester (GRP).

All structural steel members shall be hot-dip galvanized and painted. Manufacturing of steel members shall be in accordance with EN ISO 14713. Finish of the steel members shall be done with polyester-based resin with heat hardened powder. Finish color shall be selected by the Engineer from the RAL catalogue. Finish paint thickness shall be 60 to 80 µ and the adherence category class 0.

The below requirements in this section shall be applied especially for: existing steel to be rehabilitated, jointing, painted steel (Where provided), or where applicable,

Paint characteristics shall be determined taking into account the function, location of each item of equipment and type of protection required.

With the exception of surfaces to be embedded in concrete, all equipment shall be given marine protection for overseas shipment. Corrosion protection systems shall be selected (as specified herein and/or as directed by the Engineer) considering the shipment, site storage and final use conditions (including XS3 exposure).

Equipment shall be protected from the corrosive action of water when such equipment is submerged or partially submerged, and from the corrosive action of the atmosphere.

The protection of all equipment will be designed for all possible types of corrosion, namely: chemical, electrochemical and biological.

Each coat of paint shall be of a different color.

All safety components and accessories which, in contact with water, might be subject to serious corrosion or scaling, liable to cause operating faults, shall be protected from corrosion and, wherever possible, from scaling by the use of materials whose mechanical and physical qualities must meet the conditions of use imposed on the components.

1.3.2 Equipment Submerged, Partially Submerged or Submitted to Humid Environment

Equipment located in parts of the structure where humidity or condensation is high shall be protected with the same system as that used for the submerged or partly submerged parts.

On the parts of equipment inaccessible after erection, the entire protective system shall be applied before shipment to the site.

The paints system shall be an epoxy tar-based system. The system selected shall be such that it can accept a final coat at site. The minimum guaranteed thickness of the protective coating shall be 450 micrometers.

1.3.3 Equipment Exposed to the Open Air

The protection system shall be applied without the final coat.

The minimum thickness of the total intermediate coat shall be specified and guaranteed by the Contractor.

1.3.4 Parts Embedded in Concrete

The protective system for submerged parts or parts exposed to air, as applicable, shall be applied over a length of 10 cm measured from the line of penetration in the concrete

1.3.5 Machined Surfaces

A protective varnish shall be applied to the dried and cleaned surfaces either with the aid of a brush or with a spray gun. This varnish must be capable of being easily removed by the application of petrol or trichlorethylene. The Contractor supplying trichlorethylene shall warn personnel of the health hazard resulting from the use of this ingredient.

1.3.6 Internal Surfaces of Metallic Tanks

Unless otherwise specified, the internal surfaces of metallic tanks designed to contain oil shall be blast cleaned and immediately protected with two coats of oil-proof enamel paint.

1.3.7 Insides of Box Girders

The insides of box girders not accessible for painting after erection shall be subjected to a watertightness test using compressed air, unless specified to the contrary for each particular case at the written request of the Contractor. The compressed air pressure will be 1.5 bar for the test.

On completion of this test, a desiccating powder shall be blown into the box girders in order to dry the air. The aperture shall then be carefully sealed by means of a welded plate.

1.3.8 Access Ways, Platforms, Handrails, Ladders, Covers, Lampposts, Steel Stairs, Footbridges, Grating

All these items shall meet the following:

- items located on open air: protected by hot dip process galvanization;
- items located in rooms or inside a closed structure: made with aluminum, stainless steel (at least 314L) or inert materials.

1.3.9 Surfaces Inaccessible After Assembly and Erection

Surfaces inaccessible after assembly and/or erection of the equipment shall be prepared and protected using the complete system selected for the whole of the equipment before such erection and assembly are carried out.

In the event of assembly without a sufficient gap being available, a flexible seal will be installed between the various parts, after assembly.

1.3.10 Colors

The colors proposed shall be submitted to the Engineer for approval.

The colors of pipework for services shall be according to Employer's standards.

1.4 Quality Assurance

1.4.1 References

The Contractor shall furnish references of the paint manufacturers and of the paint application subcontractors.

1.4.2 Standards and Regulations

Supplies and works shall comply with the following standards or equivalent:

- Standards of the US Steel Structure Painting Council (SSPC) for corrosion and metal protection.
- European scale of rusting degree for anti-rust paint. Published by the European Committee of the association of paint printing inks and art colors (42 avenue Marceau, PARIS 8e).
- Din 55928 or Swedish standard S.I.S. 05590 or equivalent on the cleanness degree of metallic surfaces.

1.5 Documents to be Submitted

For each type of protection system, the Contractor shall submit the following documents to the Engineer for information and comment:

1.5.1 Technical Information Sheets

Technical information sheets concerning the paint used, giving the following:

1. Origin, definition, destination, composition;
2. Properties, including: recommended thickness of dry coat, graphs showing drying times, maximum and minimum coating times and pot life as a function of temperature, highest and lowest duty temperatures, flash point;
3. Conditions of application, including air temperature and humidity and temperature of the substrate;
4. Compatibility and method of protection;
5. Efficiency;
6. Packing and storage;
7. Reference to DIN standard.

1.5.2 Painting Procedure

1. Preparation of surfaces (substrate, underlying layers, damaged area),
2. Products applied and thickness of each coat,
3. Place of application;
4. Description of the paint application facilities;
5. Temperature and humidity limits.

1.5.3 Application Report

1. Daily report of the maximum and minimum ambient temperature and list of parts to be painted;
2. Daily report of the maximum and minimum humidity level in the paint application room;
3. Other pertinent information;
4. A table indicating the various items of equipment to be protected (on X-axis for example) and the various types of protection (on Y-axis for example): quality, thickness, color per coat and areas to be painted.

1.5.4 Scale of Rusting

Stereotype No. 7 of the European scale of rusting for anti-rust paint.

1.6 Storage

The storage conditions of painting products shall comply with the recommendations indicated on the supplier's technical data sheets. Non respect of these conditions may give rise to rejection of the product. In particular, the Contractor is deemed to be fully acquainted with the climatic conditions prevailing on site and shall be required to take such conditions into account.

The stores used for the storage of paints and associated thinners shall be closed and covered, thereby enabling the temperature and degree of humidity to be maintained at a level consistent with the specifications indicated on the product instructions for use.

1.7 Environmental Limitations

Sand blasting and painting work shall be carried is out only when the ambient air temperature and degree of humidity within the requirements of the product instructions for use.

Generally, all such work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40°C or drops below 5°C. The substrate temperature shall always be at least 3°C higher than the dew point.

The Contractor shall bear the cost of equipping each work station with sufficiently accurate measuring instruments. Temperature and humidity shall be recorded during paint application.

1.8 Program

The contractor shall clearly indicate in his manufacturing program and in his erection program, the global periods scheduled for the application of corrosion protection coatings.

1.9 Guarantee

1. All the protection systems adopted shall have a design life of 8 years, to be certified by the Office National D' Homologation des Garanties de Peinture Industrielle (or equivalent).
2. The performance of the protective paintwork during the Maintenance Period will be inspected by the Engineer in presence of both the Contractor and the Employer. No rust point or blister shall be accepted at the end of the maintenance period. Any necessary repair work shall be determined on the basis of the results of these inspections.

2 Products

2.1 General

1. Each coat of paint shall be of a different color.
2. Equipment exposed to ultra-violet radiation shall be given special protection. Areas to be protected in this manner shall be determined in relation to the normal operating conditions of each item of equipment.

2.2 Colors

The colors proposed shall be submitted to the Engineer for approval. For guidance purposes, the Contractor could make the choices indicated hereafter:

1. Aluminum: for equipment exposed to sunlight, the thermal effects of which could be detrimental to protection performance.
2. Moving parts in the immediate vicinity of personnel access ways shall feature black stripes 6 cm wide and inclined at 30° to the vertical.
3. The colors of pipework for services shall be according to RAL standards.

2.3 Schedules of Painting

2.3.1 Ferrous Metal Subject to Continuous or Intermittent Immersion in Water

1. Abrasive blast cleaning SA 2.5.
2. Two or three coal tar epoxy coats.
3. Minimum dry film thickness of the system not less than 450 mm.

   Or:

4. Abrasive blast cleaning SA 2.5.
5. One coat of zinc rich primer minimum thickness 40 µm.
6. Two or three coats of vinyl coal tar.

Minimum dry film thickness of the system not less than 450 µm.

2.3.2 Ferrous Metal Subject to Splash, Unfavorable Atmospheric Exposure or Humid Environment

Same as for ferrous metal subject to continuous or intermittent immersion in water.

2.3.3 Painting Schedules for Typical Outdoor Locations

1. Abrasive blast cleaning SA 2.5
2. One coat epoxy polyamide metallic zinc rich primer.
3. One coat epoxy polyamide.
4. One chlorinated rubber tie coat.
5. One coat high build chlorinated rubber.

Dry film thickness of the system not less than 220 µm.

Or:

1. Abrasive blast cleaning SA 2.5

2. One coat zinc rich epoxy paint.
3. One intermediate coat epoxy paint.
4. One top coat acrylic polyurethane paint.

Dry film thickness of the system not less than 180 µm.

2.3.4 Painting Schedules for Typical Indoor Locations

1. Abrasive blast cleaning SA 2.5.
2. One coat weldable holding primer for protection during manufacture and erection.
3. One coat of epoxy zinc rich primer.
4. One intermediate coat of epoxy paint.
5. One coat of epoxy paint.

Dry film thickness of the system not less than 150 µm.

Or:

1. Abrasive blast cleaning SA 2.5.
2. One coat of epoxy zinc rich primer.
3. One intermediate coat of modified epoxy paint.
4. One coat of modified epoxy paint.
5. Dry film thickness of the system not less than 150 µm.

2.4 Galvanizing

Galvanizing shall be applied by the hot-dip process and shall consist of a continuous coating to minimum thickness as follows:

	Average of Specimens tested µm (g/m²)	**Any Individual Specimen µm (g/m²)**
Rolled steel exposed to the atmosphere only		
t < 6 mm t > 6 mm	87 (609) 100 (700)	79 (553) 87 (609)
Rolled steel underground surface or in water	210 (1470)	165 (1155)
Cast iron and malleable iron	87 (609)	79 (553)
Bolts, nuts and washers	55 (385)	44 (308)

The zinc coating shall meet the requirements according to ASTM A123, A153, A239 and A385 or equivalent.

3 Execution

3.1 Preparation

3.1.1 General

The Contractor shall take all reasonable precautions to ensure that the protective coatings are not damaged during handling in the factory, during transport or during erection. In particular, he shall ensure that no damage is caused through the use of inappropriate packing systems.

In the event of damage, the Contractor shall make good the existing protective coating, using the same products and under the same conditions of application.

For all the equipment included in the supply, a single make of paint approved by the Engineer and identical products for identical operating conditions shall be chosen.

Regardless of where the corrosion protection coating is applied, the cost of all the necessary installations shall be borne by the Contractor.

3.1.2 Surface Preparation

3.1.2.1 Bare Metal Substrates and Damaged Areas

1. Before any treatment, the surfaces will be cleaned using an appropriate method.
2. Blast cleaning (using non-siliceous sand, corundum, treated slag or shot). The surface quality grade will be DS 2.5, minimum. The surface roughness value to be obtained after cleaning shall be defined by the paint supplier. Wet sand-blasting is prohibited.
3. Careful removal of dust.

3.1.2.2 Pre-Painted Substrates and Surface Preparation Between each Coat

1. Before carrying out any treatment, the surfaces will be cleaned using an appropriate method.
2. The surface preparation will be defined in relation to the primer applied in the workshop and to the requirements for the correct adhesion of the other coats, which will be defined by the paint supplier (surface roughness, possible removal of zinc salts, etc.).
3. Careful removal of dust.

3.1.3 Paint Coatings

The choice of place(s) for the application of the final coats shall be made in relation to the following:

1. Type of product,
2. Program and procedure of manufacture and erection,
3. Climatic conditions,
4. Mode of application of the paint,
5. Equipment, materials and personnel available,

Other factors may be taken into account.

3.2 Application in Workshop

3.2.1 General

The Contractor shall not proceed with painting of any of the equipment subject to workshop inspections and tests without the prior written approval of the Engineer.

For galvanization, all steel work shall be fully fabricated before galvanizing, no machine or shop work, boring, punching etc. will be allowed after galvanizing. Minor damage to the galvanizing resulting from transportation and erection shall be repaired at site in an approved manner, e.g. by painting with an approved zinc-rich paint, containing at least 92 weight per cent zinc powder.

After galvanizing all members shall be dipped in a dichromate solution bath to avoid formation of white rust during storage and transportation.

3.2.2 Application Report

The Contractor shall submit the application report defined as follows:

- Daily report of the maximum and minimum ambient temperature and list of parts to be painted,
- Daily report of the maximum and minimum humidity level in the paint application room,
- Other pertinent information.

3.2.3 Quality Control in Workshops

Inspection before shipment:

1. The Engineer reserves the right to inspect the paint application facilities in the Contractor's and/or his subcontractor's workshops and to ensure that they comply with the prescribed standards and painting procedure.
2. The number of coats of paint and the total thickness of the coating will be checked and the Engineer reserves the right to have the thickness of individual coats checked in his presence. On a protected surface, a test area and a number of test points shall be defined by the Engineer. The minimum measured thickness shall not be below 90% of the guaranteed thickness and the average of all measurements shall not be below the guarantee. The Contractor shall supply the measuring apparatus, which shall be of the electronic detection type (Brandl Positector or similar), giving readings accurate to within 1 micrometer. One measurement shall be taken every 0.5 m² or every 0.5 linear meters.
3. Adhesion tests shall be performed on submerged and partially submerged equipment, in accordance with DIN standard. The instruments required, in accordance with the same standard, shall be supplied by the Contractor.

3.3 Application On Site

3.3.1 General

The protective coating on surfaces damaged during handling, transportation and erection shall be repaired using the same surface preparation and products, depending on the protection system approved.

3.3.2 Inspection Before Application

Protection inspections shall be carried out jointly by the Engineer and the Contractor after:

1. Erection of completed equipment;
2. Dust removal, washing with fresh water (except where otherwise instructed by the Engineer) and drying if deemed necessary by the Engineer.

Surfaces to touch up will then be defined by mutual agreement.

3.3.3 Installations for the Application of Protective Coatings on Site

The Contractor shall install all necessary equipment for:

1. Rinsing of structural surfaces that have been in contact with a salty atmosphere during transport, with the exception of surfaces to be sand blasted at site.
2. Drying of surfaces to be sand blasted;
3. Checking of air temperature and degree of humidity at the place of work execution, together with the necessary shelters and special arrangements required for carrying out these measurements;
4. Distributing compressed air for sand blasting and paint work;
5. Removal of sand blasting dust and thinner evaporation gases;
6. The protection of ancillary equipment and structures against the projection of products, their vapors, sand and dust.

3.3.4 Surface Protection by Painting

3.3.4.1 Submerged or Partially Submerged Equipment

Reapplication of the protective coating on surfaces damaged during handling and transport, using the same products, depending on the protection system selected.

3.3.4.2 Equipment in the Open Air

1. Reapplication of the primer protection on surfaces damaged during handling or transport, using the same products, and depending on the protection system used in the workshop;
2. Application of top coat;
3. The minimum thickness of the top coat shall be defined and guaranteed by the Contractor.

3.3.4.3 Surface of Parts Embedded in Concrete

All traces of grease and scaling shall be removed prior to concreting.

3.3.5 Quality Control on Site

1. Checking of application conditions, compliance with paintwork standards and procedures.
2. Checking of surface preparation.
3. Checking of the number of coats and of the total coating thickness using testing apparatus to be provided by the Contractor.
4. If necessary, when in doubt: additional adhesion tests as per Standard NFT 30 038 standard or DIN equivalent. Testing apparatus to be provided by the Contractor.
5. Acceptance of the protection system shall be combined with the overall acceptance procedures for the equipment covered.

SECTION 02100
SITE PREPARATION

1 GENERAL

1.1 Work Included

1.1.1 Scope of Supply

This section covers all operations in connection with clearing, grubbing and stripping, including demolition of various parts of the Works sites and other locations related to the Works.

1.1.2 Limits of Supply

It is the intent of these specifications that the site preparation in connection with demolition, excavation and backfill shall be within the limit lines and grades shown on the drawings and defined herein, but the right is reserved to modify such limits and grades during the progress of the work, as may be judged necessary by the Engineer.

1.2 Related Work

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section 01000 - General requirements;

1.3 Submittals

Twenty-eight days before the beginning of the work, the Contractor shall submit to the approval of the Engineer:

A. A program of work, he intends to carry out, area by area, to enable the Engineer to assess the consequences of the clearing, grubbing and stripping works, as regards to the relevant Authority.

B. The arrangements the Contractor intends to adopt to carry out the work.

1.4 Sequencing – Scheduling

The clearing of the site shall be performed at the earliest practicable time in order to facilitate further survey works.

2 PRODUCTS

Not applicable

3 EXECUTION

3.1 Clearing

1. Clearing shall consist in removing all trees and bush, including removing of tree stump, with manual and mechanical means. Chemical means are not permitted.
2. The Contractor shall remove and eliminate all wastes at his own costs in a landfill approved by the Engineer.

3.2 Stripping and Grabbing

1. Stripping and grabbing, identified below by stripping shall consist of removing all top soil: rubbish, vegetal matters, debris and humus.
2. Stripping shall be required for all earth foundations of various types of fill and where the foundation has not been constructed by excavating.
3. No separate stripping will be required in areas to be excavated and when the excavated materials will not be used in Permanent Works.
4. The minimum depth of stripping shall be 25 cm or where this requirement is inapplicable as directed by the Engineer.
5. The Contractor shall not dispose of surplus topsoil (potential agricultural topsoil for green areas) without the written permission of the Engineer.

The under and/or above ground utilities (regardless than being operational or not, including the final closures of the landfill cells) shall be protected by the Contractor, any damage shall be rectified by the Contractor on his own expense.

3.3 Demolition

Demolition works are included in stripping; they concern all structures, pipes, roads to be demolished on the works area.

Some major specific structures to be demolished have been defined on the tender drawings.

3.4 Protection of Other Areas

1. The Contractor shall ensure that trees and other vegetation outside the areas of the permanent works and the minimal areas required for temporary works including access are protected and preserved from damage.
2. Any additional clearing required by the Contractor for construction of temporary works, and for any other purpose shall be at the Contractor's expense and shall not be carried out without the approval of the Engineer.
3. The Engineer reserves the right to reinstate any damage to vegetation and the surface of the ground beyond the areas of the Works (including temporary works) at the expense of the Contractor.

3.5 Disposal and Rearrangement of Materials

A. Stumps, roots, logs and other objectionable matter removed in the site preparation operation shall be removed from the limits of the work and disposed of.

B. Disposal areas shall be approved by the Engineer.

C. Some equipment and materials which are unobjectionable and in use by the water establishment (BMLWE) shall not be disposed of. Following the water establishment directives, they need to be either transported to other BMLWE yards or storage areas and/or they shall be rearranged in the existing or new Al-Ghadir WWTP sites

D. Other materials from clearing and stripping operations shall become the property of the Contractor and shall be at the Contractor's option burnt or removed from the site well in advance of the programmed date for the start of impoundment or disposed of as approved.

E. Burning will be permitted only if allowed by the nearby airport regulations, and at times when conditions are considered favorable by the Engineer for burning and at locations approved by the Engineer. Materials to be burnt shall be piled neatly and when in a suitable condition shall be burnt completely.

F. Piling for burning shall be done in such a manner and in such locations as to cause the least fire risk. Burning shall be thorough so that burned materials are reduced to ashes. No logs, branches or charred pieces shall be permitted to remain.

G. The Contractor shall at all times take special precautions to prevent fire from spreading to areas beyond the limits of the cleared areas and shall have available at all times suitable equipment and supplies for use in preventing and suppressing fires.

SECTION 02210
OPEN AIR EXCAVATIONS

1 GENERAL

1.1 Work Included

This section covers all operations in connection with clearing, grubbing and stripping of various parts of the Works sites and other locations related to the Works.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

- Section VII – A. General requirements;

1.3 Description

Excavation as specified under this section / as shown and noted in drawings / as directed by the Engineer, shall include, when necessary, all ripping, drilling, blasting, scaling down, supporting/shoring/protection, loading, transporting, dumping, selecting (lab and in-situ testing) and stockpiling of excavated materials in approved disposal areas and preparation of surfaces for foundations.

Attention shall be paid regarding the closeness of the project to the airport facilities, especially regarding the blasting, where appropriate clearance shall be previously provided.

1.4 Definition

1. According to the dimensions, line levels and grade as shown on the drawings or directed by the Engineer:
   a) The «elevation» line or neat line shown on the drawings is the line within which no material shall be permitted to remain.
   b) All excavations out of «elevation» line shall be considered as overbreak.
   c) "Geological overbreaks" shall be those due only to the geology of excavated material. This will not concern overbreaks due to other reasons such as the method of excavation. Classification as geological overbreak shall be decided by the Engineer.
2. Classifications of excavation types
   a) Rock excavations:
   b) Rock is defined as sound and solid masses, of such hardness and texture, that it cannot be effectively loosened or broken down by ripping in a single pass with a late model tractor mounted hydraulic ripper, equipped with one digging point of standard Manufacturer's design adequately sized for use with and propelled by a crawler type tractor rated minimum 250kW (335HP) flywheel operating in low gear.
   c) In the case where the above criterion is not convincing, rock excavation is defined as sound material with a longitudinal seismic velocity greater than 2000 m/s.
   d) All boulders or detached pieces of solid rock, more than 2.7 tons will be classified as rock excavation.
   e) Common excavations:

f) Common excavation includes all materials other than rock excavation and are also termed soil excavations. All boulders or detached pieces of solid rock less than 1 cubic meter in volume will be classed as common excavation.

3. In the event of a dispute as to classification of a material, the decision of the Engineer shall be final.

1.5 Codes And Standards

- BS 410 .....Test sieves. Technical requirements and testing.
- BS 812 .....Testing aggregates.
- BS 1377.....Methods of test for soils for civil engineering purposes
- BS 5930.....Code of practice for Site investigations
- BS 6031..... Code of practice for earthworks
- BS 6187.....Code of practice for demolition
- ISO EN 965, 964-1, 12956, 10319:..... Test of geotextile
- USBR: .....Earth Manual of "Bureau of reclamation" US Department of the Interior.
- LCPC: .....Laboratoire Central des Ponts et Chaussées.
- Equivalent ASTM standards may also be used as directed by the Engineer

1.6 Submittals

1. Mass haul diagram.
   a) Before Works execution, the Contractor shall arrange and provide to the Engineer's agreement a Mass haul diagram.
   b) This diagram will be submitted to the Engineer at least one month before Works beginning.
   c) To establish this project, the Contractor shall take into account the geotechnical investigations report included with Tender documents and further / complementary geotechnical investigations to be carried out by the Contractor.
   d) No work shall start before the Engineer has notified his complete and unreserved agreement to the Contractor who may not claim any compensation in this respect.
2. Method of work
   a) Not later than 30 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the method, sequences and equipment proposed for carrying out the work. This will include all patterns and supporting where appropriate.
   b) Not later than 30 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the planning of exploitation for quarries and borrow areas and method statements.
   c) Within two weeks of receipt of any proposed plan, the Engineer will give in writing to the Contractor, approval or rejection of that plan in whole or in part. If approval is withheld the Contractor shall submit a new plan. No rock excavation shall be started in areas for which the overall plan has not been approved by the Engineer.
   d) The Contractor will submit to the Engineer, at least one month before Works beginning, all calculation notes, documents and drawings that he will have produced about slopes stability. Works shall not begin before the Engineer's agreement concerning the technical solution

chosen by the Contractor to ensure slopes stability and safety. If supports and protections are found to be useless, justifications shall be submitted.

3. Topographical survey before any works

At least 30 days before start of any excavation work, a topographical survey - as described in § 3.1 Inspection - shall be submitted to the Engineer. The topographical benchmarks shall be pre-agreed with the Engineer.

4. Topographical survey on completion of the excavation work

On completion of each type of excavation and not later than 3 days after a topographical survey - as described in § 3.1 Inspection - shall be submitted to the Engineer.

5. Excavation records

The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work of all excavations works. When applicable the following data shall be recorded for each working face together with such other data as the Engineer may request:

- volume excavated in soil,
- volume excavated in rock,
- location and drilling pattern for rock excavation,
- number and classification of men and plant engaged,
- unusual occurrences, rockfall, unstable or soft ground and inflows of water.

1.7 Tolerances

1. Excavations shall be made to the full dimensions required and shall be finished to the prescribed lines, slopes and grades.
2. Any excavation beyond the lines, slopes and grades shown on the drawings or directed by the Engineer which is performed by the Contractor for any purpose (such as for working space) shall be kept within the limits approved by the Engineer. If such excavation should in the opinion of the Engineer, require to be backfilled, such backfilling shall be done to the satisfaction of the Engineer with material approved by the Engineer.
3. Beneath load bearing structures, foundations and other reinforced concrete work, the filling of any over excavation shall be of the same quality concrete as that required for the associated concrete structure unless the Engineer permits leaner concrete.
4. For the excavations to be covered by concrete, or core material and adjacent filters or transition the tolerances shall be as follows:
   - for the levels:

   +0

   -100 mm
   - for the horizontal dimensions:

   +100 mm

   -0
5. For other excavations the following tolerances shall be required unless otherwise shown on the Drawings or ordered by the Engineer:
   - for the levels:

   +0

-150 mm

- for the horizontal dimensions:

+150 mm

-0 mm.

2 Products

Not applicable.

3 Execution

3.1 Inspection

1. Topographical survey before works
2. Before the commencement of any earthworks the sites shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish existing ground levels and these agreed ground levels shall form when required the basis for the calculation of quantities of any subsequent excavation and filling.
3. Topographical survey on completion of excavation works
4. On completion of each type of work (common excavation, rock excavation...) the areas shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish the different volumes excavated.

3.2 General

1. The Contractor shall arrange excavation activities with due regard for the safety of the Works and the personnel on site.
2. Excavated surfaces which will remain permanently exposed shall be finished off in a neat and workmanlike manner and shall be graded to provide adequate drainage.
3. All necessary precautions shall be taken to preserve the material below and beyond the prescribed lines for excavation in the soundest possible conditions.
4. Excavations needed by the Contractor's installations shall be submitted to the approval of the Engineer.

3.3 Investigations

Before drawing up his earth movement balance, the Contractor shall carry out on the following basis all ground investigations necessary for Works execution.

1. Investigations required under this Contract,
2. Investigations to be carried out by the Contactor, the scope of works to be approved by the Engineer.

3.4 Support and Protection

1. All temporary slopes shall be made safe and protected if necessary. These protections shall include temporary supports including shoring, sheeting and bracing where necessary, the diversion/dewatering/unwatering of water and the provision and maintenance of such protections, all to be designed for the approval of the Engineer.
2. Berms shall be maintained free of fallen material.

3.5 Common Excavation

1. Common material shall be excavated to bedrock or to the lines and grades shown on the drawings or as required by the Engineer. Excavation for any structure or area shall include excavation necessary to ensure the stability of slopes associated with such structure or area.
2. Where the excavation is provided to accommodate structures, such excavation shall allow the proper placing and bracing of forms.
3. If at any point in excavation the natural foundation material is disturbed or loosened during the excavation process or otherwise, it shall be compacted in place or where directed it shall be removed and replaced with approved suitable material and compacted as preparation of foundation structure or embankment as the case required at the expense of the Contractor (all as directed by the Engineer).

3.6 Rock Excavations

1. Rock excavations shall be performed with heavy percussion tools complete with rock bits, hydraulic wedges, blasting or other specific method for rock excavation.
2. If blasting is used (after taking the approval of the Engineer and following providing the needed clearance from concerned authorities,), excavation shall be carried out utilizing a controlled perimeter blasting technique as approved by the Engineer, in order to produce smooth faces, conforming to the prescribed neat lines and to prevent or minimize the occurrence of blast, induced fractures in the rock outside the excavation lines:
   a) Presplitting on smooth blasting shall be used where shown on the drawings or directed by the Engineer for vertical or near vertical faces excavated which will be permanently exposed or which will be covered with concrete or shotcrete.
   b) Unless otherwise agreed, trim blasting techniques shall be used in all horizontal or sloping surfaces at the bottom of the excavations for all foundation of concrete structure or where required by the Engineer.
3. When necessary, the Contractor shall provide heavy duty blasting mats adequately held down to prevent damage from flying rocks.
4. Immediately following blasting and at any time during the Contract, all loose materials which appear unsafe or to endanger workmen or structure or equipment shall be scaled and removed. All materials loosened by scaling shall be removed from the excavation.
5. When required by the Engineer, concrete structure foundation shall be finished using hand tools for the last 25 cm.

3.7 Excavation in Borrow Areas

1. At least one month before any borrow area is opened the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit the area until the Engineer has given his approval.
2. All material from borrow areas shall be tested by the Contractor and approved by the Engineer.
3. At any time during the exploitation of a borrow area, the Engineer may withdraw his approval for the continued utilization of that borrow area.

3.8 Excavation in Quarry

1. At least one month before a quarry is opened, the Contractor shall submit to the Engineer a plan of operations for the working of the area and he shall not exploit it until the Engineer has given his approval.

2. All material from quarry shall be tested by the Contractor as described in these specifications and approved by the Engineer.

3.9 Trench Excavations

A. The trench must be sufficiently wide at all points to lay pipes and carry out backfilling operations around the pipes. Subject to different stipulations notified by the Engineer, the bottom width shall not be less than:

1. For one pipe:

   DN up to 600 mm: D + Minimum 0.60 (in m)

   DN above 600 mm: D + Minimum 0.80 (in m)

   in which:

   D = outer diameter of the pipe in meters.

   in which:

   D = outer diameter of the pipe in meters.

2. For n pipes in the same trench:

   (D1 + D2+…+Di) + (n-1) x C + Min 0.6/0.8 in m

   in which:

   Di = outer diameter of each pipe in meters.

   C = distance between Pipes where:

   - C ≥ (Di+Di+1) / 6 for pipe cover depth up to 4m
   - C ≥ (Di+Di+1) / 4 for pipe cover depth over to 4m

B. Trenches for welded steel pipes shall include recesses for joints. These recesses shall be 1 m wide on either side of the trench edge.

C. The bottom of the trenches is levelled at least 0.15 to 0.20 m below the level planned for the outer invert of the pipe (in line with thickness of the bedding material as shown in drawing). If there should be any rocks projecting above this level, they shall be completely excavated and the corresponding cavities filled in if necessary.

D. The normal depth of the trenches shall be such that the thickness of fill above the outer soffit of the pipe shall not be less than 0.80 m, Otherwise, a concrete encasement shall be provided as shown on drawings and/or as directed and approved by the Engineer

E. The Contractor shall take all necessary measures to avoid cave-ins and ensure safety for staff, if necessary, by sloping, shoring, planking or reinforcing the sides of the excavation (including trench-box) using all means suited to the nature of the soil and as approved by the Engineer.

F. Excavated material shall not be deposited less than 3 m from the edge of the trench.

G. The Contractor shall excavate trenches in such a way that the pipes he lays can be connected to those installed previously by the Owner.

H. The trench shall have a warning tape above the pipe at a height of 0.45 m from the natural ground level (NGL).

I. An HDPE pipe/duct housing control and instrumentation cables at shallower depth, is also included in the trench.

3.10 Disposal of Excavated Materials

1. Excavated material shall be disposed of in disposal areas indicated on the drawings or agreed by the Engineer at any distance.
2. Disposal areas shall be well drained and left in tidy, safe and stable conditions.
3. In so far as they may be suitable and comply with the Specifications, materials arising from excavations shall be used in the Works.
4. All surplus or unsuitable excavated materials shall be disposed to spoil banks at locations shown on the drawings or accepted by the Engineer.
5. All necessary measures shall be taken not to obstruct natural drainage courses with the spoil banks.
6. Suitable slopes shall be given to the surface to ensure drainage.
7. Maximum heights will be determined by the Engineer.

3.11 Preparation of Excavated Surfaces

1. Common excavations for foundations
   a) The surface shall be cleaned of all loose/soft material.
   b) The granular foundation soils shall be compacted to a depth of 0.20 m to a minimum dry density of 95% of the maximum dry density according to the standard proctor test (NF P 94 093 or equivalent). The compaction shall be done at optimum water content.
   c) For foundations on open-graded gravels (such as free-draining materials), the in-situ foundation material shall be compacted in such a manner as to achieve a uniform density throughout of 92% of the relative density.
   d) The surface shall be free from standing or running water. If needed, dewatering and/or unwatering shall be designed and provided by the Contractor for the approval of the Engineer.
   e) Where the ground surface under any compacted embankment or structure is not suitable, as determined by the Engineer, after the required excavation or removal of top soil, the Contractor shall further remove the unsuitable material to such depth and in such area as may be directed.
   f) The foundation just after compaction/treatment/preparation shall receive a layer of blinding concrete.
2. Rock excavations for foundations
3. After completion of the excavations and other required works such as rock bolting, etc., the following operations shall be carried out where relevant:
   a) Any degraded or weathered material located beyond the theoretical excavation lines shall be removed. This includes materials in cracks, seams, faults and cavities, which will be removed by using hand tools or compressed air water jet to a depth where sound material is encountered or until the depth cleaned out is at least four times the width of the surface opening. The rock-foundations shall also be inspected for any subsidence and/or sinkhole-preparation to be treated by the Contractor,
   b) Rock surfaces shall be thoroughly cleaned by the use of high-pressure water air jet. Brushing shall be employed if appropriate and required by the Engineer.
   c) After having been cleaned out, cracks, seams, faults, cavities (including subsidence and/or sinkhole preparation), trenches or pits shall be filled with concrete, shotcrete or cement slurry

as required or agreed by the Engineer. A levelling / backing course (such as well compacted quarry runs aggregate base course) may also be required by the Engineer.

d) A first cleaning shall be carried out to allow a geological examination of the foundation surface and to define possible treatment if required.

e) After geological acceptance by the Engineer, the final cleaning of the rock shall be made not more than 24 hours before concreting and the rock shall be kept wet and protected from the sun.

3.12 Possible Demolition of Buried or Exposed Structures

If masonry or concrete structures are encountered during excavation works, the Contractor must first inform the Engineer then proceed with the demolition, removal, transport and disposal of this material. Such material shall be treated as sound rock. These works shall not give the right to any additional payments.

Some structures are defined to be demolished as specified in other tender documents (Performance specifications, Tender drawings, …)

The Contractor shall afford all needed safety measures while demolishing the structures.

In addition, the Contractor shall remove and preserve all the valuable materials and equipment, located inside the structures to be demolished, in appropriate and safe storage locations, as directed by the Engineer.

3.13 Restoration of Borrow Areas and Quarry

1. At the end of works, all borrow areas and quarry shall be left in safe conditions as approved by the Engineer.
2. The surface of borrow areas shall be left in a reasonably smooth and even condition as approved by the Engineer.
3. Borrow areas shall be drained by the means of open ditches where necessary to prevent the accumulation of standing water.

3.14 Special Instructions for Certain Kinds of Excavations

1. Bottom of excavation
2. Any hollows or lenticles that are more compressible than the bottom of the excavation in general must be drained and replaced by material with similar compressibility to that of the sound earth at the same depth.
3. In particular, before the blinding concrete is put in place, the bottom of excavations must be carefully inspected in order to check the quality of the foundation sand and gravel (substitution of pockets of clay-loam by carefully compacted clean/replaced with sandy-gravely soil (Engineering Fill and/or Aggregate Subbase Course), over a minimum depth of 0.5m under the base slab).
4. Excavations at the foot/toe of slopes
5. Care must be taken when excavating at the foot/toe of slopes so as to avoid any movement of the slope.
6. Acceptance of excavations for structures
7. A band of at least 0.80m in width will be provided outside the formworks everywhere around the structures to be built.
8. The Contractor shall supply the Engineer with:

- Earthworks in conformity with the approved design drawings with an altitude tolerance in compliance with § 1.7 Tolerances,
- Bearing capacity checked by plate load tests (as directed by the Engineer) according to ASTM D 1194 / IS 1888 / DIN 18134 (or equivalent), and until reaching the maximum soil pressure under envelop of ultimate combination.

3.15 Keeping Excavations Dry During Works

1. General
2. Except for any special dispensations which might be granted by the Engineer, the Contractor must protect the excavations from water, at his own expense, so that the works can be performed in dry conditions.
3. The method used to drain water from the excavation is the responsibility of the Contractor and must be submitted for the Engineer's opinion, and possibly the opinion of a geotechnical consultancy where the stability of the ground may be involved.
4. Runoff outside the site

   The crest of the excavation shall be surrounded by drain slots to collect runoff outside the excavation and evacuate it at a suitable distance from the excavations.
5. Water from the walls and bottom of excavations

   Characterized sources or even single threads of water must be intercepted or diverted at their outlets. The measures used for this purpose must not cause soil erosion or subsidence.

   During the works, the Contractor must ensure that the dumping of excavated material and the circulation of machines do not cause landslips.
6. Water collection and pump sump

   If, because of the site layout, particularly in the case of buried structures, water in the excavations cannot be evacuated by gravity, the water must be collected in a sump from which it can be pumped (unwatering). The Contractor must take all the necessary precautions to prevent wash out of fines.
7. Dewatering or water table drawdown

   The Contractor's attention is drawn to the precautions to be taken to avoid effects of water table drawdown on existing structures (stability, wash out of fines, etc.).

   Before any operation, the contractor must submit to the Engineer the calculation notes related to dewatering/unwatering established by a geotechnical consultancy, as well as the precautionary measures taken for the existing structures.

SECTION 02215
TRENCH EXCAVATION

1 GENERAL

1.1 Work Included

This section covers trenching and backfilling works, including the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; handling and storage of all excavated material (including lab and in-situ testing), transportation and disposal of excess excavated material; all necessary sheeting/trench-box, shoring and protection work; preparation of subgrades; pumping/unwatering and dewatering as necessary; protection of adjacent properties; pipe embedment; surfacing and grading; destruction and restoration of roads and other related works.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents and in particular:

- Section VII – A. General requirements

1.3 Definitions and Abbreviations

1.3.1 Definitions

1. Classifications of excavation types

   - Rock excavations:

     Shall include the removal of hard and solid rock in continuous layers or boulders that cannot be broken up by ordinary excavating equipment including rooter, and which necessitate the use of pneumatic tools or wedges for loosening and removal.

     In the case where the above criterion is not convincing, rock excavation is defined as sound material with a longitudinal seismic velocity greater than 2000 m/s.

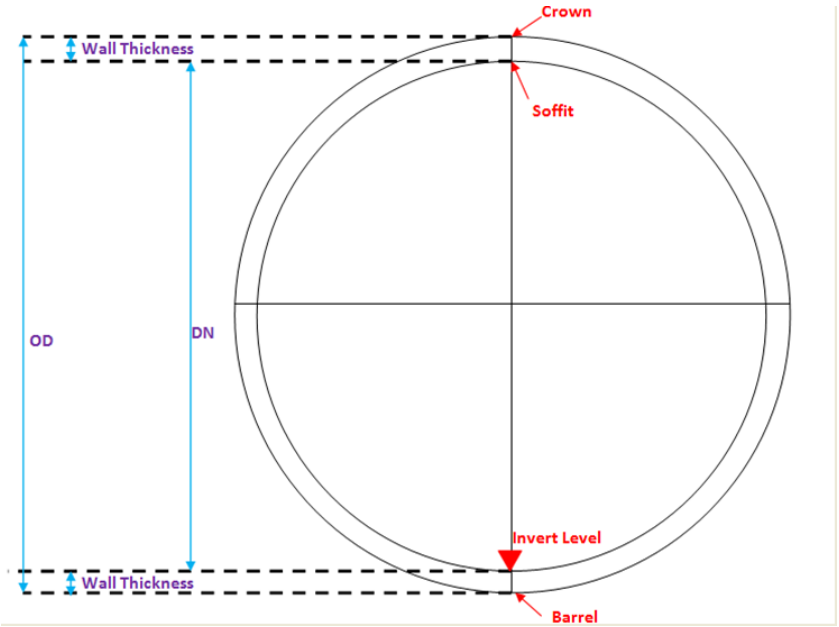
     All boulders or detached pieces of solid rock, more than 1.5 tons will be classified as rock excavation.

   - Common excavations:

     Common excavation includes all materials other than rock excavation and are also termed soil excavations. All boulders or detached pieces of solid rock less than 1.5 tons in volume will be classed as common excavation.

2. In the event of a dispute as to classification of a material, the decision of the Engineer shall be final.

3. Designation of different elevations of pipes is as follows:



1.3.2 Abbreviations

4-days soaked CBR: 4-days soaked California Bearing Ratio (at 92%, 95%, 96% and 98% of maximum dry density)

1.4 Codes and Standards

BS 410	Test sieves. Technical requirements and testing.
BS 812	Testing aggregates.
BS 1377	Methods of test for soils for civil engineering purposes
BS 5930	Code of practice for site investigations
BS 6031	Code of practice for earthworks
USBR	Earth Manual of "Bureau of reclamation" US Department of the Interior.
LCPC	Laboratoire Central des Ponts et Chaussées.
BS 434 Part 1	Bitumen Road emulsions
BS 594	Hot rolled asphalt for roads and other paved areas
BS 598	Sampling and examination of bituminous mixtures for roads and other paved areas
BS 4987	Coated macadam for roads and other paved areas
NF P 18561	Aggregates – Measurement of the flakiness index
ASTM	American Society for Testing and Materials (Standards as referenced throughout this Section)

1.5 Topographical and Geotechnical Investigations

Refer to Section 02300 and 02400 and to Section VII – A. General Requirements.

1.6 Submittals

1. Mass haul diagram:

Before Works execution, the Contractor shall arrange and provide to the Engineer's agreement a mass haul diagram, taking into account the width and depth of the trenches, the necessity of shoring the trenches, the volume of pipes and imported material for bedding and lateral protection, etc. and based on estimated quantities of reused material.

This diagram will be submitted to the Engineer at least one month before Works beginning.

To establish this project, the Contractor shall take into account the geotechnical investigations report included with Tender documents and further / complementary geotechnical investigations to be carried out by the Contractor.

No work shall start before the Engineer has notified his complete and unreserved agreement to the Contractor who may not claim any compensation in this respect.

2. Method of work:

Not later than 30 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the method, sequences and equipment proposed for carrying out the work. This will include all patterns and supporting where appropriate.

Not later than 30 days prior to programmed commencement of the work, the Contractor shall provide the Engineer with the planning of exploitation for quarries and borrow areas and method statements.

Within two weeks of receipt of any proposed plan, the Engineer will give in writing to the Contractor, approval or rejection of that plan in whole or in part. If approval is withheld the Contractor shall submit a new plan. No excavation shall be started in areas for which the overall plan has not been approved by the Engineer.

In case of trenching without shoring, the Contractor will submit to the Engineer, at least one month before Works beginning, all calculation notes, documents and drawings that he will have produced about slopes stability. Works shall not begin before the Engineer's agreement concerning the technical solution chosen by the Contractor to ensure slopes stability and safety. If supports and protections are found to be useless, justifications shall be submitted.

3. Topographical survey before any works:

At least 30days before start of any excavation work, a topographical survey -as described in section 3.2 - shall be submitted to the Engineer. The topographical benchmarks shall be pre-agreed by the Engineer.

4. Excavation records:

The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work of all excavations works. When applicable the following data shall be recorded for each working face together with such other data as the Engineer may request:

- volume excavated in soil,
- volume excavated in rock,
- unusual occurrences, rockfall, unstable or soft ground and inflows of water.

1.7 Tolerances

1. Excavations shall be made to the full dimensions required and shall be finished to the prescribed lines, slopes and grades.
2. Any excavation beyond the lines, slopes and grades shown on the drawings or directed by the Engineer which is performed by the Contractor for any purpose (such as for working space) shall

be under the responsibility of the Contractor and the cost of such excavation shall be borne by the Contractor.

3. The following tolerances shall be required for excavations unless otherwise shown on the Drawings or ordered by the Engineer:

   for the levels:

   +0

   -50 mm

   for the horizontal dimensions:

   +50 mm

   -0 mm.

2 Products

2.1 Material for Bedding, Lateral and Top Protection

Material for bedding, lateral and top protection of the pipes shall consist of sand from an approved source or fine aggregates.

Basic sand material shall comply with the following requirements and ASTM C33 (or as noted in drawings):

- D maxi = 4mm (nominal maximum aggregate size).
- Fraction passing 0.074mm sieve (square openings): 5%.
- Plasticity index: < 6.

Other fine to medium material according to ASTM C33, can be proposed by the Contractor and subject to approval by the Engineer provided it can be easily compacted against the base of the pipe.

2.2 Backfill Material

2.2.1 General

Backfill and fill material (including Engineering Fill 0/127mm) shall be suitable excavated material, natural or processed mineral soils obtained from off-site sources, or graded crushed stones or gravel, or as noted in drawings.

Backfill and fill material shall be free from all organic material, trash, snow, ice, frozen soil, or other objectionable material which can't be properly compacted. The backfill material shall not contain either any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tires, ashes, refuse, oil or soil soaked with oil. Stones removed during trench excavation may be used in the second stage of backfilling as specified herein.

Soft, wet, plastic soils, clay soils having a natural in-place water content in excess of 30 percent, soil containing more than 5 percent (by weight) fibrous organic material, and soil having a plasticity index greater than 30 shall be considered unsuitable for use as backfill and fill material.

Backfill and fill material shall have a maximum of one percent expansion when testing is performed on a sample method to 95 percent of maximum dry density at a two percent below optimum moisture content under a 490 kg/m² surcharge.

Reuse of excavated material is authorized and subject to testing by an independent laboratory in order to establish its compliance with the use. Test shall be made on samples taken from the trench at intervals not exceeding 150 m as a minimum.

2.2.2 Selected Backfill Material

Selected Backfill of fill material (including Engineering Fill 0/127mm) shall not contain stones, granite blocks, concrete blocks, masonry rubble, or any material larger than 127 mm in any dimension provided that this material is not more than 20 percent of the backfill or fill material.

Selected backfill shall comply with the following requirements (and/or as noted in drawings):

- D maxi = 127 mm.
- Organic matter content < 0.1%.
- Fraction passing 0.074 mm sieve (square openings) between 5 and 15%.
- Plasticity index IP ≤ 6.

2.3 Materials for Backfilling in Case of Underwater Laying

In particular cases where pipelines shall be laid in a trench containing water (no possible drainage of water), material for bedding, lateral and top protection (bedding and surrounding material) shall consist of gravel size number 5 according to ASTM C33, as well as fines in selected backfill material shall be limited to 7%

In addition (if needed and/or as directed by the Engineer), the bedding and surrounding material shall be provided with a permeable geotextile lining.

Characteristics of above-mentioned materials shall be subject to the Engineer's approval.

2.4 Material for Road Restoration

2.4.1 Base Course

Base course material shall be as noted in drawings, and shall also be tested as noted in drawings for the approval of the Engineer. In addition, the base course material shall be tested for quality during the execution as directed/required by the Engineer.

2.4.2 Subbase Course

Subbase course material shall be as noted in drawings, and shall also be tested as noted in drawings for the approval of the Engineer. In addition, the subbase course material shall be tested for quality during the execution as directed/required by the Engineer.

2.4.3 Aggregates for Ready Mix Asphalt-Concrete

The crushed coarse and medium aggregates shall be according to ASTM C33, and shall be tested for approval as directed by the Engineer.

The combined gradation of the aggregates for wearing course shall be as follows:

Sieve Size (mm)	Passing (%)
19	100
12.5	75 – 99
9.5	60 - 85
4.75	35 - 55
2	19 – 34
0.84	12 – 25
0.59	10 – 22
0.425	8 – 19
0.25	5 – 15
0.149	4 – 12
0.074	2 – 8

The combined gradation of the aggregates for binder course shall be as follows:

Sieve Size (mm)	Passing (%)
25	100
19	75-100
12.5	57 – 83
9.5	45 - 70
4.75	30 - 50
2	18 – 35
0.84	8 – 24
0.59	5 – 20
0.425	4 – 16
0.25	3 – 12
0.149	2 – 8
0.074	1 – 6

The fine aggregate including any blended filler (passing sieve number 200), shall have a plasticity index of not more than 4% when tested in accordance with ASTM D424.

3 Execution

3.1 General

1. The Contractor shall arrange excavation activities with due regard for the safety of the Works and the personnel on site.
2. Trenches which will remain open during a long period (more than a day) and during night shall be protected to prevent any collapse.
3. Adequate drainage shall be implemented during execution in order to provide a dry trench bottom, except in certain circumstances where drainage could damage the walls and provoke collapses.
4. All necessary precautions shall be taken to prevent people from falling down the open trenches, during day and during night.

3.2 Topographical Survey Before Work

Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey, record existing ground elevations and stake the location of trenches to be excavated. The topographical benchmarks shall be pre-agreed by the Engineer.

3.3 Existing Utilities and Subsurface Structures

3.3.1 Taking into Account of Existing Utilities and Subsurface Structures

A. Before beginning excavation operations, the Contractor shall contact the relevant Departments and Authorities and notify them of his intention to begin excavation operations.

B. The Contract Drawings may show certain utilities or other structures or facilities believed to exist in the working area, the exact location of which may vary from the locations indicated. Other structures or facilities may not be shown. The Drawings do not show all existing subsurface structures or utilities.

C. It shall be the responsibility of the Contractor to determine the exact location of such pipelines, subsurface structures and/or utilities (such as final closure of the landfill cells) ahead of his Work by exploratory excavation or other means and to take suitable precautions to prevent damage to

them and to prevent interruption of the services that such facilities provide. If they are broken or damaged (else than the areas as noted in drawings for applying the final closure of the landfill cells), they shall be restored by the Contractor or the relevant Authority at the Contractor's expense.

D. Where necessary, the Contractor shall use hand tools to excavate test pit prior to excavation to determine the exact locations of existing utilities. It shall be the responsibility of the Contractor to make such explorations sufficiently in advance of construction to enable the Engineer to approve modifications, if any, to be made to the pipeline, structure or conflicting utility. The Contractor shall obtain the permission of the Engineer before commencing any test pits and shall fence, mark and protect them, as required by the Engineer. Test pits shall be refilled by hand as soon as practicable after the necessary information has been obtained.

E. Wherever the excavation approaches water mains or service connections, sewers, conduits, cables or other underground facilities, the excavation shall be continued by means of hand tools. Where necessary, the Contractor shall provide temporary support for the existing utilities to prevent damage during his operations. Notwithstanding these provisions, if damage to existing utilities results from the Contractor's operations, such damage shall be repaired without delay by the Contractor or the cost of such repairs shall be borne by the Contractor.

F. If damage to existing utilities causes disruption to Contractor's Schedule of Work by delaying Work in the area of such damage, the Contractor shall readjust his Schedule, methods of working and resources so that critical dates in the Schedule for the completion of the Contract are not affected.

G. In case of pipelines, subsurface structures and/or utilities encountered in the work coincide with the pipeline route (else than the areas as noted in drawings for applying the final closure of the landfill cells), the Engineer shall have the authority to change the plans and order a deviation from the line and grade, or arrange with the Owner of the existing structures and/or utilities for removal, relocation or reconstruction of the structures and/or utilities in accordance with the procedures of the Owner.

3.3.2 Operation of Existing Utilities

The existing utilities must be kept in continuous operation throughout the construction period. No interruption will be permitted which adversely affects the level of service provided.

Provided permission is obtained from the Owner and Engineer in advance; portions of the existing utilities (such as final closure of the landfill cells) may be taken out of service for short periods corresponding with periods of minimum service demands. Such permission will not relieve the Contractor of any of his responsibilities under the Contract.

3.4 Site Preparation

The Contractor shall prepare the site for construction by clearing, removing and disposing all items not indicated on the Drawings to remain or so defined by the Engineer.

The Contractor shall perform the clearing and grubbing of top soil, if any, consisting mainly of removal of trees, tree stumps, bushes, wastes, loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300 mm from the natural ground level. All materials resulting from the above operations shall be removed from the site (after selection and taking the approval of the Engineer), loaded and transported and off loaded, spread and levelled to approved dumps as directed by the Engineer.

The Contractor shall obtain relevant excavation and road cutting permits as required to commence the work.

The Contractor shall ensure that trees and other vegetation and items outside the areas of the permanent works and the minimal areas required for temporary works including access are protected and preserved from damages.

If sign posts or any other items must be temporarily removed for the execution of the works, they shall be reinstalled after completion of the works. The cost of such work is supposed to be included in the contract price.

3.5 Staking Out

The Contractor shall stake-out the Works as shown on the Drawings and secure the Engineer's approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out, the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval.

3.6 Removal of Pavement and Roads

The Contractor shall remove pavement and road surfaces as a part of the trench excavation, and the amount removed shall depend upon the width of trench specified for the installation of the pipe and the width and length of the pavement area required to be removed for the construction of valve chambers, thrust blocks, manholes, or other structures.

The width of pavement removed along the normal trench for the installation of the pipe shall not exceed the top width of the trench specified. The widths and lengths of the area of pavement removed for the construction of valve chambers, thrust blocks, manholes, or other structures shall not exceed the maximum linear dimensions of such structures by more than 500 mm on each side.

Wherever, in the opinion of the Engineer, existing conditions make it necessary or advisable to remove additional pavement, the Contractor shall remove it as directed by the Engineer but shall receive no extra compensation therefore.

The Contractor shall use such methods, either drilling or chipping/milling, as will assure the breaking of the pavement along straight lines. The cut must be sharp and approximately vertical (unless it is shown in drawings). The Engineer's representative may require that the pavement be cut /milled with asphalt cutting / milling machine without extra compensation to the Contractor.

3.7 Trench Excavations

3.7.1 Dimensions of Trenches

A. The trench must be sufficiently wide at all points to lay pipes and carry out backfilling operations around the pipes. Subject to different stipulations notified by the Engineer, the bottom width, between shoring if existing, shall not be less than:

1. For one pipe:

   DN up to 600 mm: D + Minimum 0.60 (in m)

   DN above 600 mm: D + Minimum 0.80 (in m)

   in which:

   D = outer diameter of the pipe in meters.

2. For n pipes in the same trench:

   (D1 + D2+…+Di) + (n-1) x C + Min 0.6/0.8 in m

   in which:

   Di = outer diameter of each pipe in meters.

C = distance between Pipes where:

- ~ C ≥ (Di+Di+1) / 6 for pipe cover depth up to 4m
- ~ C ≥ (Di+Di+1) / 4 for pipe cover depth over to 4m

B. Trenches shall be of such extra width, when required, as will permit the convenient placing of timber support, shoring or sheeting and bracing (including trench-box) and handling of specials.

C. Trenches for welded steel pipes shall include recesses for joints. These recesses shall be at least 1 m wide on either side of the trench edge.

D. The depth of trenches shall be in accordance with the longitudinal profiles of the construction drawings, taking into account extra depths for pipe wall and bedding (depending on indications provided in the construction drawings) or as defined by the Engineer.

E. The bottom of the trenches is levelled at least 0.15 to 0.20 m below the level planned for the outer invert of the pipe (in line with thickness of the bedding material as shown in drawing). If there should be any rocks projecting above this level, they shall be completely excavated and the corresponding cavities filled in if necessary.

F. The normal depth of the trenches shall be such that the thickness of fill above the crown of the pipe shall not be less than 0.80 m. Otherwise, a concrete encasement shall be provided as shown on drawings and/or as directed and approved by the Engineer.

3.7.2 Excavation Procedures

3.7.2.1 General

A. Excavation works will be classified according to the quality of the material to be excavated, in two classes as defined in section 1.3 - Definition (“common excavation” and “rock excavation”).

B. The Contractor shall take all necessary measures to avoid cave-ins and ensure safety for staff, if necessary, by sloping, shoring, planking or reinforcing the sides of the excavation using all means suited to the nature of the soil and as approved by the Engineer at his own expense.

C. The excavated material shall be placed alongside the trench in such a manner as not to interfere with the work and to prevent its falling down into the trench and creating surcharge load against stability.

D. The trench bottom shall be straight and even so as to provide a good support for the pipe on its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating. Where needed, the trench bottom / trench formation shall be removed and replaced with selected backfill (Engineering Fill 0/127mm) to a depth as directed by the Engineer.

E. The Contractor shall excavate trenches in such a way that the pipes he lays can be connected to those installed previously by the Owner.

F. Laying of ducts for different types of networks in the same trench shall not be permitted, except otherwise indicated by the Engineer.

G. If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting voids shall be backfilled by well graded material at the Contractor’s expense and thoroughly compacted to an acceptable Proctor as directed by the Engineer. If the excavations are for a structure or a manhole, then the voids shall be filled by class B150 concrete.

3.7.2.2 Common Excavation

1. Common material shall be excavated to bedrock or to the depth shown on the drawings or as required by the Engineer.

3.7.2.3 Rock Excavations

1. Rock excavations shall be performed with heavy percussion tools complete with rock bits, hydraulic wedges or other specific method for rock excavation.
2. Blasting shall be avoided in cities or nearby buildings except in some particular cases after approval by the relevant authorities. If blasting is intended to be used, the Contractor shall obtain all necessary permits, have a bailiff report made in the vicinity of the works, including exteriors and interior of buildings, underground structures, etc. and present to the approval of the Engineer a detailed program of the basting showing techniques employed and ways of ensuring security and minimizing adverse effects.

3.7.2.4 Protection Of Trenches

The trench walls shall be as vertical as possible (unless as shown /noted in drawings) without however causing collapses and damages to persons or equipment or materials.

Additional protection may be required by the Engineer in certain cases such as (but not limited to):

- Unstable soil
- High depth with or without surcharge
- Low to moderate depth with surcharge
- Local regulation

If there is sufficient place on each side of the trench, the trench walls can be sloped to a grade acceptable with the soil characteristics (depending on geotechnical investigations to be carried out by the Contractor). Additional protection such as temporary cover of the trench walls with a specific lining might be required by the Engineer.

In case there is not sufficient place of if there are neighboring foundations in the vicinity that need to be protected from a possible collapse of the trench, then shoring of trench shall be implemented at Contractor's expense. The type of shoring (or the use of sheeting / trench-box) shall be defined by the Contractor depending on the soil characteristics, presence of water, depth, etc. and presented to the approval of the Engineer.

3.7.2.5 Mechanical Excavation

The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, building, culverts or other existing property, utilities or structures above or below ground. In all such locations hand excavation shall be used. The Contractor will be held responsible for making good at his own cost all additional damage to road surfaces and private lands caused by the use of mechanical excavators.

Mechanical equipment if used for trench excavation shall be of a type approved by the Engineer. Equipment shall be so operated that the trench bottom can be controlled and that uniform trench widths and vertical sides (unless as shown / noted in drawings) are obtained.

3.7.2.6 Excavation In Confined Areas

In confined areas, where the passage of excavating equipment is impossible, or where the Engineer deems the use of such equipment impracticable or undesirable for any reason whatsoever, trench excavation shall be done by hand. All requirements specified above for common excavation shall also apply to trench excavation by hand.

3.7.2.7 Dewatering/Unwatering

Possible presence of water in the trenches shall previously be assessed through a geotechnical survey. This survey shall establish the quantity of water that need to be pumped in order to dry out the trenches before laying of the pipes.

Cost for dewatering/unwatering the trenches shall be included in the contract price. If it is not accounted for in a particular unit price of the BoQ, it is supposed to be included in the other unit prices.

Before any operation, the Contractor must submit to the Engineer the calculation notes related to dewatering/unwatering established by a geotechnical/hydro-geotechnical consultancy, as well as the precautionary measures taken for the existing neighboring structures.

The Contractor's attention is drawn to the precautions to be taken to avoid effects of water table drawdown on existing neighboring structures (stability, wash out of fines-caused settlement, etc.).

3.7.3 Reuse and Disposal of Excavated Materials

1. In so far as they may be suitable and comply with the Specifications/notes in drawings, materials arising from excavations shall be used in the Works.
2. Materials suitable for backfill will be stockpiled on the site (after testing and approval of the Engineer) at sufficient distance from the sides of the excavation to avoid over-loading and prevent cave-ins or mixing with the concrete during the construction of thrust blocks or chambers.
3. All surplus or unsuitable excavated materials shall, after taking the approval of the Engineer, be disposed of in approved dumps or disposal areas and the Contractor shall abide by the relevant local regulations.

3.8 Excavation for Valve Chambers or Manholes and Thrust Blocks

3.8.1 Excavation for Valve Chambers and Manholes

Excavation for the concrete valve chambers or manholes shall be carried out to the dimensions, lines and grades shown on the Construction Drawings or required by the Engineer.

Wherever the depth of the excavation or the nature of the soil makes it necessary to avoid caving in, the Contractor shall excavate the walls with a slope or brace and support the excavation as directed by the Engineer.

Should nevertheless earth slides occur (it is to be re-noted by the Contractor that all type of unshored excavations are Contractor's sole responsibility), the Contractor shall remove the material resulting therefrom, clean the excavation of all stones, clods and other loose material and shall provide a clean excavation surface in which concrete can be cast according to the required dimensions and grades.

Should it appear that the bottom of the excavation does not provide a solid base for the casting of the concrete floor, the Contractor will be required to consolidate/densify the bottom using 4-stroke engine tamper having a basic weight at least 55Kg and increasing the moisture content, if required, until the required density is obtained, and placing concrete class B150 as blinding, all as directed by the Engineer. In addition to above and where needed, the bottom of excavation shall be removed and replaced with selected backfill (Engineering Fill 0/127mm) to a depth as directed by the Engineer.

Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the over-excavation with class B150 concrete or shall be filled with the concrete of which the structure is cast. In the case of over-excavation in the walls, whether caused by careless work or by the necessity to prevent slides by excavating to a slope or for any other reason, the Contractor shall remove all loose material from the excavation, cast the walls of the structure to the dimensions shown on the Drawings and fill the spaces between the structures and the sides of the excavation with selected backfill (Engineering Fill 0/127mm and/or subbase course) in compacted layers.. The material of the selected backfill shall be moistened if necessary, and shall be compacted until the required density is obtained.

3.8.2 Excavation for Thrust Blocks

Excavation for concrete anchoring/thrust blocks shall be performed according to the shapes and dimensions shown on the construction drawings. The bottom and sides of the excavation shall be smooth, even, and solid so that concrete can be cast against them. Wherever necessary, such surfaces shall be moistened and consolidated/densified using 4-stroke engine tamper having a basic weight at least 55Kg, to make them suitable for the casting of concrete against them. In addition, and where needed, the bottom of excavation shall be removed and replaced with selected backfill (Engineering Fill 0/127mm) to a depth as directed by the Engineer. Any over excavation on the bottom or sides shall be cleaned, smoothened out, and filled with concrete cast integrally with the block.

After the block has been cast, and subject to the Engineer's approval, it shall be covered with compacted selected backfill (Engineering Fill 0/127mm) up to the natural ground surface. The surplus of excavated material shall be removed and transported to approved dumps as directed by the Engineer.

3.8.3 Special Instructions for Certain Kinds of Excavations

Any hollows or lenticels that are more compressible than the bottom of the excavation in general must be drained and replaced by material with similar compressibility to that of the sound earth at the same depth, or where needed, the bottom of excavation shall be removed and replaced with selected backfill (Engineering Fill 0/127mm) to a depth as directed by the Engineer.

3.9 Backfilling

3.9.1 General

Backfilling described in this section concerns bottom, lateral and top protection of the pipelines as well as backfill up to the top of the trench or the basement of the road / bottom of road foundation.

Every section of the pipeline shall be covered as soon as possible after being lowered into the trench, but no section of the line shall be covered without survey of the actual position of the pipeline and express approval of the Engineer. Each section shall be backfilled after the pipe has been placed in its final position in the trench and after all welded joints and bends have been coated and all defects in the pipe coating repaired.

Backfilling shall be done carefully to prevent displacement of the pipes or injury to the pipes and their coating. The backfill material shall completely fill the entire space between the pipe and the trench sides, without leaving any voids.

The backfill material shall comply with specifications defined in section 2.2.

Backfilling shall be done so as not to spoil the road or disrupt its continuity.

3.9.2 Lateral and Top Protection of the Pipe

Unless otherwise specified by the Engineer, material for bottom, lateral and top protection of the pipe shall be as defined in section 2 here above and shall be placed up to 200 to 300 mm over the crown of the pipe and for the full width of the trench as shown/noted in drawings.

3.9.3 Backfilling of Trenches in Natural or Deserted Areas

Final Backfill of the trench above the lateral and top protection of the pipe shall be as far as possible by reusing excavated material, possibly after treatment (liming or cementing for example) and/or selection, if approved by the Engineer. If such material is not suitable for backfilling, imported material (such as Engineering Fill 0/127mm) shall be used as defined in section 2 here above.

The backfill shall be spread evenly on all sides, in layers not exceeding 300 mm (or less, as directed by the Engineer in line with type and gradation) measured before compaction, thoroughly wetted and compacted by rolling, tamping, or vibrating with mechanical compacting suitable equipment. .

If settlement takes place, the Contractor shall immediately deposit additional fill to restore the level of the ground.

3.9.4 Backfilling of Trenches in or Adjacent to Streets

Final Backfill of the trench above the lateral and top protection of the pipe shall be by using well graded approved Selected Backfill material (Engineering Fill 0/127mm) as specified in section 2 here above.

The Selected Backfill (Engineering Fill 0/127mm) shall be spread evenly on all sides, in layers not exceeding 300 mm measured after compaction, thoroughly wetted and compacted by rolling, tamping, or vibrating with mechanical compacting suitable equipment, to 95 percent of maximum dry density. Where these methods are not practicable, compaction shall be done by using carrier (such as excavator)-driven hydraulic plate compactor weighing at least 140 kg. The materials in this case shall be spread and compacted in layers not more than 250 mm in compacted-thickness. If necessary, sprinkling shall be employed in conjunction with hydraulic plate compaction.

The sub-base for road foundation, shall consist of one layer of approved quarry runs aggregate subbase course (200mm and 300mm thick), wetted and compacted to 96 percent of maximum dry density, as described in the subsequent section 3.10.

3.9.5 Backfilling of Trenches on Lands with Excessive Slopes

For trenches on lands with slopes exceeding 15 percent, the backfilling needs to be at least as permeable as the original soil.

And the trench shall be provided with 300 mm wide stone partition built across the trench every 10 meters length. These partitions shall be constructed over the first stage of the backfill (bedding and surrounding) up to the natural ground level, and shall exceed the trench width with 200 mm from each side inside the ground.

3.9.6 Restoring Trench Surface (Except for Reinstatement of Pavement)

Where the trench is adjacent to paved streets, in shoulders, sidewalks, or in cross-country areas, the Contractor shall thoroughly consolidate/densify the backfill (Engineering Fill 0/127mm) and shall maintain the surface as the work progresses. If settlement takes place, he shall immediately deposit additional backfill to restore the level of the ground. In some areas it may be necessary to remove excess materials during the clean-up process, so that the ground may be restored to its original level and condition.

The surface of any driveway or any other area which is disturbed by the trench excavation and which is not a part of the paved road shall be restored by the Contractor to a condition at least equal to that existing before work began.

Where the pipes are laid in cross-country areas, and where the danger of erosion exists, the uppermost 300 mm part of the trench shall be backfilled with Engineering Fill 0/127mm material.

Where the pipes are laid in cultivated lands, lands planted with grass or private land, the restoring of trench surface shall be as a minimum as it was before the works. In case of plantations, the thickness of agricultural topsoil shall be to a minimum of 150 mm (or as directed by the Engineer according to type of plant).

Restoring trench surfaces on roads shall be done as described in subsequent section 3.10.

On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater (overland-flow) into the natural drain courses and away from the pipeline trench.

Where the pipeline crosses natural drainage channels, an opening in the trench shall be made using reinforced concrete encasement to avoid interference with normal drainage of the surrounding land.

3.9.7 Backfilling Around Structures

Backfilling using Engineering Fill 0/127mm around structures shall be implemented as described here above for trench backfilling (or as shown / noted in drawings).

Backfilling shall be done as promptly as the work permits, but not before completion of inspection, testing, approval, and recording of location of underground utilities, and as directed by the Engineer.

Backfill materials (Engineering Fills) shall not be placed on surfaces that contain excessive moister, preventing specified degree of compaction, or on surfaces found by the Engineer that needs to be replaced.

3.9.8 Backfilling Below Pipelines or Other Structures Crossing the Trench

Where other pipelines or structures cross the trench, backfilling around that pipe or structure shall be made with mass-concrete, depending on levels of the pipelines or structures, and as directed by the Engineer.

3.10 Reinstatement of Pavements and Structures

3.10.1 Temporary Reinstatement of Pavements

In order for the trench to be well compacted without any depression before final road reinstatement, a temporary reinstatement shall be implemented to allow traffic during the period between backfilling and final road reinstatement.

All road surfaces shall be broomed and hose-cleaned immediately after backfilling (Engineering Fill 0/127mm) and regularly during all the temporary period until final road reinstatement.

Trenches on roads shall be maintained with the compacted backfill (Engineering Fill 0/127mm). If depression occurs on the trench, extra backfill shall be applied and compacted.

On high traffic roads, the road authorities might request to apply a temporary layer of asphalt concrete thick enough to bear the high traffic until applying the final reinstatement. The cost of applying such layers shall be included in the price of road reinstatement.

Dust control measures shall be employed at all times.

3.10.2 Final Reinstatement of Pavements and Structures

Unless otherwise shown on the Drawings or mentioned in the bill of quantities, the Contractor shall restore all pavements, sidewalls, sidewalks, curbs, gutters, shrubbery, fences, poles, sod, or other property and surface structures removed or disturbed as a part of the work to a condition equal to that before the work began, and shall furnish all incidental labor and materials.

No permanent pavement shall be restored unless and until, in the opinion of the Engineer, the condition of the backfill (Engineering Fill 0/127mm) is such as to properly support the pavement and not before written approval from the Engineer to commence such works.

Where pipelines pass underneath asphalted roads, the final layers of the trench backfill (Engineering Fill 0/127mm) shall be furnished as follows (after excavation of the backfill/Engineering Fill 0/127mm surface to the required depth):

Base course and Subbase course:

The base and subbase courses shall have characteristics as described in section 2 here above. It shall be applied on the backfilling (Engineering Fill 0/127mm) and spread in uniform layers not exceeding 250 mm and 300mm loose-lift thickness (respectively). Each layer shall be properly compacted.

4-days soaked CBR values >= 80% and >=60% shall be achieved for the base and subbase courses at 98% and 96% compaction (respectively) to be approved.

The asphalt concrete (binder and wearing courses) shall be applied on the base course as shown/noted in drawings

1. Aggregate subbase and base courses as specified in section 2.
2. Content of asphalt penetration grade 60/70 (ASTM D946) shall be between 4 and 5.5 percent.
3. Marshall stability test (ASTM D1559) shall not be less than 800kg and 950kg for binder and wearing courses (respectively), and the flow values shall be between 2mm and 3.5mm.
4. Degree of compaction not less than 97 percent of the standard specimen specific gravity (ASTM D1074)

3.11 Restoration of Damaged Surface Structures

If any pavement, trees, shrubbery, fences, poles, or other property and surface structures have been damaged, removed, or disturbed by the Contractor, whether deliberately or through failure to carry out the requirements of the contract documents, state laws, municipal ordinances, or the specific direction of the Engineer or through failure to employ usual and reasonable safeguards, such property and surface structures shall be replaced or repaired at the expense of the Contractor. If the Employer specifies that the replacements or repairs shall be made by the Contractor, the Contractor shall replace or repair and restore the structures to a condition equal to that before the work began and to the approval of the Engineer and shall furnish all incidental labor and materials.

3.12 Possible Demolition of Buried or Exposed Structures

If masonry or concrete structures are encountered during excavation works, the Contractor must first inform the Engineer then proceed with the demolition after the approval of the Engineer, removal, transport and disposal of this material. These works shall not give the right to any additional payments else than excavation.

The Contractor shall refer also to Section 02210 -3.12.

SECTION 02220
EMBANKMENT, FILL AND BACKFILL

1 GENERAL

1.1 Work Included

This section covers all operations in connection with:

1. Backfill / Engineering Fill around all structures.
2. All embankments
3. Road embankments.
4. Backfill of trenches.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 02100 - Site preparation.

C. Section 02210 - Open air excavations.

1.3 Description

Fill and backfill work as specified under this Section shall include filling or backfilling with Engineering Fills as shown/noted in drawings, and as approved by the Engineer, and built up in horizontal layers, the thickness of which shall be determined according to trials carried out by the Contractor before the beginning of any filling work.

1.4 References

1. BS 1377:1990: Methods of test for soils for civil engineering purposes
2. ASTM: American Society for Testing and Materials.
3. USBR: Earth Manual of "Bureau of Reclamation"
   US Department of the Interior.

1.5 Submittals

1. A mass haul diagram shall be submitted to the Engineer in the form and following the description given in Section 02210 "Open air excavations".
2. This mass haul diagram shall be drafted and submitted together with the general mass haul diagram of Section 02210.
3. At least one month before starting the filling operations, the Contractor shall submit a complete programme showing the proposed filling program including quantities and origin of materials (quarries).
4. At least one month before starting the filling operations, the Contractor shall submit to the Engineer a detailed method statement covering the filling operations and material placement.

5. On a weekly basis, the Contractor shall submit to the Engineer summary sheets giving the results of all controls (quality and compaction) performed during the week on a format to be agreed with the Engineer.
6. The Contractor shall provide the Engineer each day with one copy of the record for the previous day's work for all fill work including:
   a) quantities of materials placed with their type,
   b) location of the material placed,
   c) number and classification of men and plants/quarries engaged,
   d) weather during the day,
   e) inflows of water or any other unusual occurrence.

1.6 Tolerances

1. All fill and backfill shall be constructed to the lines and dimensions shown on the Drawings or as required by the Engineer.
2. For compacted fill and backfill, the following tolerances shall be required unless otherwise shown on the Drawings or ordered by the Engineer:
   - level (vertical) = +0, -5 cm,
   - dimension (horizontal) = +15, -0 cm (on the dimension of fill).

1.7 Controls

All the controls required in the present Specification and notes in drawings, shall be performed in a laboratory that will have chosen with the agreement of the Engineer.

2 PRODUCT

2.1 General

1. Fill and backfill materials shall be quarry-runs (crushed), or from designated on-site borrow areas, subject to their compliance with the relevant Specifications and approval of the Engineer.
2. All fill and backfill materials shall be well graded in accordance with the USC classification system.
3. All materials as specified hereinafter shall be subject to the prior approval of the Engineer

2.2 Engineering Fill 0/406.4mm

The material shall comply with the notes in drawings.

2.3 Engineering Fill 0/127mm

The material shall comply with the notes in drawings

2.4 Sand Layer

The material shall be according to ASTM C33 (and/or as noted in drawings), and shall comply with the following requirements:

- D maxi = 4 mm (nominal maximum).
- Fraction passing 0.074mm sieve (square openings): 5%.
- Plasticity index: < 6.

3 EXECUTION

3.1 Inspection

1. Before the commencement of any fill works the site shall be surveyed by the Contractor in conjunction with the Engineer's Representative to establish existing ground levels and these agreed ground levels shall form when required basis for the calculation of quantities of any subsequent filling.
2. No fill shall be placed in any section of the Works until the foundation has been inspected and approved by the Engineer.
3. Placing of a layer shall not be done until the preceding layer has been inspected and accepted by the Engineer.

3.2 General

1. All backfill operations shall be performed in the dry.
2. Prior to the commencement of placing backfill materials adjacent to structures, the backfill areas shall be cleared of all remaining concrete forms, other temporary works and unsuitable materials, and shall be subject to the approval of the Engineer.
3. The backfill materials shall be placed in such manner as to ensure that they can be satisfactorily compacted without damage to the structure.
4. The sequence of filling behind or around a structure and the maximum difference in height at any time between fill levels shall be approved by the Engineer.
5. Filling around structure is permitted only if the structure is completely achieved, or if the unachieved part is not necessary to handle earth pressure. In all case, approbation of the Engineer is required before filling around any structure.
6. Filling around liquid retaining structure shall begin only after validation of watertightness tests.
7. Sheeting and timbering supporting the excavations shall be removed, step by step, to prevent any settlement.
8. Where instructed by the Engineer, timbering and sheeting shall be left in place.
9. Unless otherwise directed by the Engineer, backfill material shall not be placed and compaction shall not be permitted adjacent to concrete for 14 days after the placing of concrete, and compaction of backfill material placed above buried concrete shall not be permitted to be carried out with vibrating rollers within at least 70 cm vertically of the surface of the concrete.
10. Where instructed, selected granular fill material (such as ground-covering-gravel as shown/noted in drawings, but not limited to) approved by the Engineer shall be placed around (and/or within) the structure.
11. A special care shall be given to compaction along concrete structures and at all locations where easy access is not possible. At these locations all the required criteria for each type of fill shall be fulfilled.

3.3 Engineering Fills Around Structures

1. Engineering Fills shall be placed and compacted as noted in drawings.
2. Test Pad

Prior to the commencement of Contract Earthworks on site, the Contractor shall propose a methodology for the Compaction of soils / engineering fills / subbase and base courses in accordance with the requirements of this Specification, for approval by the Engineer.

The Contractor shall demonstrate their methodology consistently achieves the requirements of the Specification by constructing a number of test pads (minimum 20m dimension), to determine number of passes needed for each type of material (by using 12-ton-static vibratory smooth roller) to achieve the required compaction. The sheep-foot rollers shall be used in compaction of cohesive soils.

The Contractor shall undertake in situ field density tests in accordance with the testing requirements of this Specification, sufficient to satisfy the Engineer that the required material parameters are achieved.

If changes occur in the nature or the origin of the soil / engineering fills / subbase and base courses used during the works or at the request of the Engineer, new test pads shall be performed.

Each type of material shall be tested for quality and compaction during the execution (in addition to stage of material submittal for approval) as directed by the Engineer (and/or as noted in drawings)

Final acceptance of each material shall only be made after they have been dumped, spread, compacted and tested (quality and compaction).

3.4 Engineering Fill 0/127mm for Backfilling of Trenches

1. General

Every section of the pipeline shall be covered as soon as possible after being lowered into the trench, but no section of the line shall be covered without pipe surveying and express approval of the Engineer.

Each section shall be backfilled after the pipe has been placed in its final position in the trench and after all welded joints and bends have been coated and all defects in the pipe coating repaired.

Backfilling shall be done carefully to prevent displacement of the pipes or injury to the pipes and their coating. The Engineering Fill 0/127mm shall completely fill the entire space between the pipe and the trench sides, without leaving any voids.

Care shall be taken that the Engineering Fill 0/127mm does not contain any electrodes, scrap iron, fragments of timber or shrubs, roots, broken skids, tires, ashes, refuse, oil or soil soaked with oil.

On hillsides or sloping ground, furrows or terraces shall be provided across the pipeline trench to direct the flow of rainwater into the natural drain courses and away from the pipeline trench.

The bedding and surrounding as well as backfilling shall be as described in paragraphs 3.9.1 to 3.9.5 of Section 02215.

SECTION 02232
ROADS

1 GENERAL

1.1 Work Included

1. Roads and related works inside the project boundaries (including internal roads).
2. The Contractor shall be responsible of the design (including in-situ and lab testing as directed by the Engineer and/or as noted in drawings), the construction, the maintenance and reinstatement of the various access road (s) to the Site Works.
3. The Contractor shall in consequence take all necessary arrangements to build the access road (s) in accordance with local Standards and Regulations.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 01010 - Corrosion protection;

C. Section 02100 - Site preparation

D. Section 02210 - Open air excavations

E. Section 03100 - Formworks

F. Section 03200 - Reinforcement

1.3 Standards and Regulations

AASHTO Standard Specifications for Highway Bridges (12th Edition 1977) and Interim Specifications, 1979.

Standard Specifications for Construction of Roads and Bridges – FHWA,

A Policy on Geometric Design of Highways and Streets – AASHTO,

Guide for Design of Pavement Structures – AASHTO

BS 434 Part 1 Bitumen Road emulsions

BS 594 Hot rolled asphalt for roads and other paved areas

BS 598 Sampling and examination of bituminous mixtures for roads and other paved areas

BS 812 Testing aggregates

BS 1377 Methods of test for soils for civil engineering purposes.

BS 4987 Coated macadam for roads and other paved areas

NF P 18561 Aggregates – Measurement of the flakiness index

Equivalent ASTM Standards, and ASTM Standards as referenced throughout this Section

1.4 Submittals

All documents concerning the quality of materials and all the results of routine tests prescribed in the present Section (and/or noted in drawings) shall be submitted to the Engineer, at the frequency and on the form agreed with the Engineer at the start of the Works.

1.5 Tolerances

The surface at each stage during the construction of the roads shall comply with the requirements set out below.

« Specified level » shall be the level shown on the Drawings, or deduced by reference to the finished road level and minimum layer thicknesses.

« Smoothness » shall be measured as the maximum gap beneath a 3.0 m long straight-edge used longitudinally or beneath a template, to suit the specified camber shape of the road, used traversely.

Surface	Tolerance from specified level (mm)	Smoothness (mm)
Sub-grade (formation)	+0 to -25	-
Engineering Fill 0/127mm	+0 to -25	-
Subbase course	+5 to -15	15
Base course	+5 to -10	10
Binder and Wearing courses	+5 to -5	5

In addition, the wearing course shall have no back-fall from any drainage point.

Immediately before the construction of any layer, the surface on which it is to be laid shall be tested for accuracy of formation and smoothness, and if any areas are found to be outside the specified tolerances such areas shall be scarified, reshaped, recompacted, broken out and replaced, or otherwise treated until the specified smoothness and accuracy are obtained.

Notwithstanding the above requirements, no layer of road construction shall have a thickness less than the thickness shown on Drawings.

2 PRODUCTS

2.1 General

All the hereafter materials shall be as noted in drawings, and shall have the prior agreement/approval of the Engineer.

2.2 Engineering Fill 0/127mm

Engineering Fill 0/127mm shall be as noted in drawings, and shall also be tested as noted in drawings for the approval of the Engineer. In addition, the Engineering Fill 0/127mm shall be tested for quality during the execution as directed/required by the Engineer.

2.3 Sub-Base Course

Subbase course material shall be as noted in drawings, and shall also be tested as noted in drawings for the approval of the Engineer. In addition, the subbase course material shall be tested for quality during the execution as directed/required by the Engineer.

2.4 Base Course

Base course material shall be as noted in drawings, and shall also be tested as noted in drawings for the approval of the Engineer. In addition, the base course material shall be tested for quality during the execution as directed/required by the Engineer.

2.5 Aggregates for Ready Mix Asphalt-Concrete

The crushed coarse and medium aggregates shall be according to ASTM C33, and shall be tested for approval as directed by the Engineer.

The combined gradation of the aggregates for wearing course shall be as follows:

Sieve Size (mm)	Passing (%)
19	100
12.5	75 – 99
9.5	60 - 85
4.75	35 - 55
2	19 – 34
0.84	12 – 25
0.59	10 – 22
0.425	8 – 19
0.25	5 – 15
0.149	4 – 12
0.074	2 – 8

The combined gradation of the aggregates for binder course shall be as follows:

Sieve Size (mm)	Passing (%)
25	100
19	75-100
12.5	57 – 83
9.5	45 - 70
4.75	30 - 50
2	18 – 35
0.84	8 – 24
0.59	5 – 20
0.425	4 – 16
0.25	3 – 12
0.149	2 – 8
0.074	1 – 6

The fine aggregate including any blended filler (passing sieve number 200), shall have a plasticity index of not more than 4% when tested in accordance with ASTM D424.

The prime and tack coating as well as road signing and marking shall be included in the unit price of asphalt concrete.

2.6 Controls

The frequency of the tests shall be as required by the Engineer according to the results of previous tests and material variations.

3 EXECUTION

3.1 Inspection

No excavation and fill shall start without prior agreement of the Engineer.

3.2 General

All fill operations shall be performed in the dry.

The fill materials shall be placed in such a manner as to ensure that they can be satisfactorily compacted without damage to adjacent structures.

Unless otherwise directed by the Engineer, backfill material shall not be placed and compaction shall not be permitted adjacent to concrete for 14 days after the placing of concrete, and compaction of backfill material placed above buried concrete shall not be permitted to be carried out with vibrating rollers within at least 70 cm vertically of the surface of the concrete.

A special care shall be given to compaction along concrete structures and at all locations where easy access is not possible. At these locations all the required criteria for each type of fill shall be fulfilled.

Moisture content of materials may have to be adapted by drying or moistening operations, in order to fulfil the requirements of the present Specification.

3.3 Investigations

The Contractor shall carry out, if necessary, all surveys and investigations required for a proper and safe execution of the Works

3.4 Engineering Fill 0/127mm

Prior to any fill, area of the embankment shall be cleared and stripped as required in Section 02100 "Site preparation" or otherwise directed by the Engineer.

Placing and compaction shall be adapted to the material used according to its grading and plasticity in order to achieve a 4-days soaked CBR value in-situ more than or equal to 45% at 95% of maximum dry density.

3.5 The Engineering Fill 0/127mm Shall be Placed and Compacted as Noted in Drawings Sub-Grade Preparation

Prior to receiving the Engineering Fill 0/127mm / Engineering Fill 0/406.4mm or sub-base course, the sub-grade shall be graded to the line and levels shown in the Contractor's approved drawings that is to be in line with tender drawings.

Once the required level is obtained, the sub-grade material shall be compacted to a depth of 200 mm minimum.

Compaction shall be achieved by means of a smooth (or sheep-foot according to type of subgrade soil) drum vibrating roller 12-ton-static class.

The number of passes shall be adapted from Test Pad.

- All soft/loose areas shall be replaced with Engineering Fill 0/127mm to a depth as directed by the Engineer, and shall be brought to the correct level after compaction.
- The subgrade shall be tested for Gradation, Atterberg Limits, 4-days soaked CBR at 95% proctor compaction and Proctor Density (as directed by the Engineer) prior to start compaction, and for Field Density after compaction.

3.6 Subgrade Soil Replacement

The need of subgrade soil replacement shall be according to AASHTO flexible pavement design and/or as noted in drawings / as directed by the Engineer, however; it is to be noted that in general subgrade soils having 4-days soaked CBR less than 20% (at 95% maximum dry density) may need to be removed and replaced with Engineering Fill 0/127mm to a depth as directed by the Engineer.

3.7 Base Course

Base course material shall be as noted in drawings, and shall also be tested as noted in drawings for the approval of the Engineer. In addition, the base course material shall be tested for quality during the execution as directed/required by the Engineer.

If needed/where needed, the aggregate base course may be treated with cement as directed by the Engineer.

The base course material shall be spread longitudinally in uniform layers not exceeding 250 mm loose-lift thickness.

Each layer shall be compacted to 98% of the maximum dry density, and compaction shall be done at optimum water content.

4-days soaked CBR ≥ 80% shall be achieved for the base course to be approved.

3.8 Related Works

3.8.1 Precast Curbstone and Concrete Gutter

The precast curbstone and concrete gutter shall be as shown / noted in drawings.

3.8.2 Sidewalk

The sidewalk shall be as shown / noted in drawings.

3.8.3 Road Marking and Signing

Marking:

These works shall consist of preparing shop drawings, furnishing and application of the roadway markings for the guidance, control and safety of vehicular traffic.

The Contractor shall submit a written request to the Engineer for his approval of shop drawings, all traffic marking materials and specification details, including samples of paints to be used in roadway marking.

Approval of material shall be obtained by the Contractor before ordering any traffic marking materials.

Thermoplastic (TRP) or cold (RCP) reflectorized paints (white and yellow) as requested by the Engineer shall be used in roadway marking according to AASHTO M247/M248/M249.

The surface on which markings are to be applied shall be cleaned by sweeping and air blasting or as directed by the Engineer.

Marking shall not proceed when there is moisture on the surface or the air is misty, or the surface temperature of the wearing course is below 10°C; or when wind or other conditions may cause a film of dust on the surface during the application.

The Subcontractor shall premark each installation of marking prior to application; the premarking shall be a guide in placing the roadway markings. Application of the markings shall not be done until the premarking has been inspected and approved by the Engineer.

To ensure optimum adhesion, the TRP (2.5mm thick) shall be applied in a molted state within the temperature range recommended by the manufacturer.

The RCP shall be applied in 2 passes with a minimum of six weeks between each pass. Final thickness of dry, unbeaded coat of RCP shall not be less than 300 microns.

The markings shall be protected for a period of time necessary to allow for drying and curing of the paints (according to the manufacturer's recommendations).

A tolerance of 12mm over and 3mm under the specified line width shall 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 30 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 shall 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 at the Contractor's expense.

All markings shall maintain a minimum retro-reflectivity of 100 millicandelas up to the end of the Defects Liability Period following completion of the final application of the paint.

All marking and painting shall be guaranteed by the Contractor against any defect in material, workmanship, and performance during the whole defect liability period of the TRP or RCP. If any defect arises due to material or workmanship, it shall be rectified by the Contractor at his own expense.

A. Broken center line: Single broken longitudinal white line, 12cm wide shall be used in passing zones. The broken line shall consist of 9 meters gap with 3 meters stroke.

B. Unbroken center line: Double unbroken longitudinal white line, each 12cm wide and separated by a space of 10cm shall be used in no passing zones such as vertical and horizontal curves and where the sight distance is equal to or less than 145 meters (level of service D). Double unbroken longitudinal white line shall not be less than 120m in length. If the actual no passing distance is less than 120m, the additional length of double unbroken longitudinal white line shall be added at the beginning and end of the no passing zone.

C. Unbroken edge lines: Single unbroken longitudinal yellow line, 20cm wide shall be used within a setback of 15cm from the edge of the traveled-way.

D. Broken continuity edge lines: Single broken longitudinal yellow line, 20cm wide with 1m strokes and 1m gaps shall be used at intersections.

Signing:

Road signing shall consist of preparing shop drawings, furnishing and installing all road signs complete with footings, bases, posts, and all other parts and appurtenances necessary for installation in accordance with the Specifications given below and as directed by the Engineer.

The Contractor shall submit a written request to the Engineer for approval of shop drawings, all traffic sign materials, giving makes, types, and specification details, including samples of complete road signs, to be used for road signing.

Approval of material shall be obtained by the Contractor before ordering any road signs.

A. Concrete Bases (for Road Signs): Road sign base dimension and quality of concrete shall be as directed by the Engineer.

B. Bolts: Bolts, nuts and washers shall be of stainless-steel conforming to ASTM A-276 chroming-nickel grade with minimum yield strength of 2400 kg/sq.cm.

C. Posts: Posts shall be manufactured from one of the following materials:

   Steel in the form of structural hollow sections or rolled steel joists hot-dip galvanized after fabrication. The weight of the zinc-coating shall be a minimum of 450 grams per square meter.

   Aluminum in the form of drawn tubes complying with grades 6063 – TF or 6082 – TF of BS 1471 or bars or extruded tubes or sections complying with grades 6063 – TF or 6082 – TF of BS 1474.

   The top of posts should be closed or capped with a PVC cap.

D. Sign Plates: Sign plates shall be constructed from one or more of the following materials: Sheet aluminum and sheet aluminum alloy of minimum thickness 3.0 mm for flat plate (non-bent edge) signs.

Sign plates shall be non-porous, smooth, flat, rigid, and weatherproof and shall not rust or deteriorate. They shall be cut and smoothed so that there are no sharp edges. The corners shall be rounded off to a minimum radius of 30 mm. Any trade mark or other printing shall be carefully removed with a lacquer thinner.

Sign Sheeting and Sign Face Construction:

A. The sign faces shall be made with wide angle reflective high intensity sheeting which shall be processed onto the plate. The Manufacturer's trade mark or name and sheeting grade shall be clearly shown as a non-removable built-in mark on the sheeting. Sheeting material shall be accompanied by certificate of compliance listing its detailed specifications and identifying the standards to which it complies (ASTM D-4956 or approved equivalent)

B. The base of the sign shall be normally of white, blue, green or yellow wide angle high intensity reflective sheeting.

C. Prior to application of reflective film, the signs shall be cleaned and shall be wax free. They shall be degreased by vapor or by alkaline immersion and etched by scrubbing with abrasive cleaners, such as medium fine steel wool. They shall be rinsed thoroughly and dried with hot air before applying any reflective material.

D. The sheeting shall be cut by any standard method by a band saw or a power guillotine. The cutting tool shall be clean and sharp. The sheeting shall be cut from face side and held securely during cutting to avoid shattering and edge chipping.

E. The sheeting after application to the sign base shall not come off the edges nor shall it peel off nor warp. The surface shall be smooth, flat and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weatherproof.

F. The sheeting of different reflective colors shall have a life of 10 years (outdoor at-site life) after application to the face of the sign.

G. The back face of the sign plate shall be treated and painted so that the life of the two faces remains the same, i.e. 10 years.

No sign shall be erected prior to the Engineer's final approval of the location.

Erection of Signs:

A. All signs shall be mounted approximately at right angles to the direction of, and facing, the traffic they are intended to serve.

B. To get maximum effectiveness from reflecting sheeting, the sign shall be properly located and shall be faced 3 degrees away from the road.

C. To avoid specular glare, the sign face shall be titled back two or three degrees (about 1 cm per 26 cm of sign height).

D. Signs shall be installed at the locations approved by the Engineer and in accordance with the approved samples and materials.

E. All sign components shall withstand a wind load of >=150 kg per square meter of sign surface without permanent deformation.

F. Sign plates shall be attached to the posts with stiffeners, bolts, and screws which shall be painted in the same color as the corresponding area of the sign plate.

G. For single post- mounted signs, a locking pin shall be incorporated into the sign plate attachment system to prevent rotation of the sign plate around the axis of the post.

H. Excavations for concrete bases shall be provided to a depth, which will permit the installation of the post and the base to the depth requested by the Engineer (calculation notes shall be provided by the Contractor). All loose material shall be removed from excavation and bearing surface of the concrete base shall be cleaned and cut to a first surface prior to the placement of concrete base.

All signs shall be guaranteed by the Contractor against any defect in material and workmanship for a period of min. 10 year from the date of completion of the Works under the Contract. If any defect arises due to material or workmanship, it shall be rectified by the Contractor at his own expense.

Reflectivity of the signs shall be tested prior to the issue of the Certificate of Completion and again prior to the Issue of the Defects Liability Certificate. They may also be assessed at any other time during the Defects Liability Period to ensure conformance with manufacturers specifications. The Contractor shall provide assistance in terms of traffic management provision and the provision of support labors, testing equipment and materials for the duration of testing when requested by the Engineer.

3.9 Controls

The frequency and nature of the tests (quality and compaction) shall be as required by the Engineer (and/or as noted in drawing) depending on the results of previous tests and material variations.

3.10 Maintenance Works

The Contractor shall properly maintain all roads, both permanent and temporary at the Engineer's satisfaction.

Such maintenance shall include all things necessary to maintain the roads in an operational and safe condition for the vehicle and weather condition for which the particular road is designed, and shall include, but not limited to, repairs to foundation and road surface, clearing of drains, repairing or supplementing signs, and clearing and stabilizing batter and fill slips.

Upon completion of the Contract and before the issue of Taking Over Certificate, all roads constructed, upgraded and/or used by the Contractor shall be left in good condition to the satisfaction of the Engineer.

The asphalt works for the required permanent roads shall be done at the end of works, when the circulation of heavy trucks (heavy construction traffic) is not likely to occur. If the Sub-base or Base courses are damage during construction works, the Contractor shall repair it according to the specifications and at the satisfaction of the Engineer before asphalt works (with no extra cost to the Client). For temporary roads, the Contractor can propose a design different from the specifications, provided he demolishes it at the end of works to build the permanent roads according to the specifications. In all cases, the price items for roads in the Bill of Quantities include all temporary, maintenance and permanent road works.

SECTION 02300
GEOTECHNICAL INVESTIGATION

1 SCOPE

The purpose of the work specified herein is to determine the type, nature and characteristics of subsurface materials and the extent and conditions of the various materials of foundation soils and conclusion of soils bearing capacity and to identify any potential geotechnical problem (sliding, instability, settlement…) and to determine the depth and degree of improvement. This is to be accomplished by means of core drilling, field testing (any kind of in-situ testing as directed by the Engineer), sampling and analysis, laboratory testing. The Contractor will provide access roads as he deems necessary for the execution of work. The Contractor will also provide a report summarizing and interpreting field and laboratory results.

2 QUANTITIES AND LOCATION OF HOLES

The locations of the drill holes to be executed by the Contractor shall be as requested by the Engineer. The Engineer reserves the right to increase or decrease the quantity of work for the Contract items to such an extent that the total contract amount would be increased or decreased by 50 percent with no change in Contract unit prices. In case of test pits required by the Engineer, these will be paid as unclassified excavations.

3 MOBILISATION AND DEMOBILSATION

a) Mobilization: mobilization shall consist of the delivery to the site of all plant, equipment, materials, and supplies to be furnished by the Contractor; the complete assembly in satisfactory working order of all such plant and equipment on the job; and the satisfactory storage at the site of all such materials and supplies.

b) Demobilization: demobilization shall consist of the removal from the site of all plant and equipment after completion of the work and shall include restoration of the area as requested and approved by the Engineer.

4 INSPECTION

No work shall be performed in the absence of the Engineer unless authorized by him. The Contractor shall not remove casing or equipment from any completed boring or test pit except with the express permission of the Engineer and not until the Engineer has had the opportunity to obtain all relevant data prior to removal.

5 RECORDS

The Contractor shall keep accurate driller's logs and records of all work accomplished under this Contract and shall deliver complete, legible copies of these logs and records to the Engineer on completion of the work in each hole or pit, or at other times as he may be directed. All such records shall be preserved in good condition and order by the Contractor until they are delivered and accepted. The Engineer shall have the right to examine such records at any time prior to their delivery to him. Separate logs shall be made for each hole and test pit. The following information shall be included on the logs or in the records for each hole:

1. Full information on the location, type of boring, diameter, ground elevation, inclination.

2. Location, elevation, depth, type, and number of each sample taken.
3. Driving energy and blow count data for each 15-centimeter penetration of drive sampler and 30-centimeter penetration of casing where the casing is driven.
4. Average rpm and hydraulic advance pressure of drill rig on undisturbed samples, cores, and casing, where the casing is advanced by drilling.
5. Length in centimeters of sampling or coring drive or run.
6. Length and percent of recovery for all samples and cores.
7. Driller's classification or description by depths of the materials sampled, cored, or penetrated, including a description of thickness of zones, moisture conditions, and of conditions of compactness or stiffness of soils materials encountered. This classification or description shall be made immediately following the taking of the samples or cores.
8. Size and lengths of casing used in each bore hole and where added.
9. Elevation of rock if encountered.
10. Elevation of depth of water in holes, daily, at the start of work and after completion of the bore hole until true water table conditions have been established as approved by the Engineer.
11. Elevations and depths of seepage tests and artesian measurements.
12. Elevations and depths at which drill water is lost and regained, and amounts and color of return water.
13. Elevation and depth of bottom of hole.
14. Dates and time by depths when test-pitting, drilling, sampling, seepage testing, and artesian measuring operations were performed.
15. Time required for drilling each run.
16. Time required for seepage tests and artesian measurements.
17. Pressure employed in seepage tests and artesian measurements.
18. Any changes in the drilling action which would be supplemental information to the sampling or coring.
19. Any information or data that the driller may deem pertinent or that may be requested by the Engineer.

The presence of the Engineer or the keeping of separate drilling records by the Engineer shall not relieve the Contractor of the responsibility for the work specified in this paragraph.

6 CONTAINERS

a) General The Contractor shall furnish litter size wide mouth jars, 10kg capacity moisture proof bags, undisturbed sample and core boxes, and accessories meeting the specified requirements, or approved as equal by the Engineer. The Contractor shall furnish as many containers as may be required. All such containers will become the property of the Engineer and the cost thereof shall be included in the Contract price for the applicable item for which payment is provided.

b) Core Boxes. Longitudinally partitioned core boxes constructed of lumber or other approved materials, shall be used for all rock cores, selected cores of soil, and selected cores of weathered zones taken from within the rock. Where the Contractor elects to advance a hole by coring in overburden, such core as may be designated by the Engineer shall also be placed in core boxes. The soil and weathered zones shall be preserved in undisturbed boxes or core boxes as directed by the Engineer. As many core boxes as may be required shall be used in

submitting each core or group of cores. Core boxes shall be completely equipped with all necessary partitions, covers, hinges, screws for holding down the cover, identification plates, tags and other accessories.

7 LABELS

Each bag and core box shall have printed or typewritten labels shall be identified with water-proof and wear-proof labels or markings indicating the following:

Project

Hole No._____ Location_____

Jar No._____ of_____ Jars

Bag No._____ of_____Bags

Top Elev. of Hole_____

Depth of Sample_____to_____

Description of Material_____

8 BORINGS

a) General. The Contractor shall make vertical borings of minimum 101 mm in overburden and rock. Coring will be continuous from the top of rock to the bottom of hole.

b) Equipment and Supplies. The Contractor shall furnish and use sufficient numbers of drill rigs and associated equipment to successfully complete the project within the designated time scheduler. The drill rigs shall be capable of drilling vertical holes to a depth of at least 40 meters. Some rigs shall be provided with whirling capability but all rigs shall be provided with hydraulic feed mechanic lams and catheads, and capable of taking drive samples and double tube core barrel overburden / rock cores to the depths required. The Contractor shall supply such equipment or accessories necessary for proper positioning of vertical borings.

All borings may be drilled with minimum 101 mm double tube core barrel. Drilling mud will not be allowed because of permeability testing requirements.

The Contractor shall provide sufficient heavy-duty casing of such a type to be driven or drilled through the overburden to sound rock. The Contractor shall furnish drill rods, piping, pumps, water, tools, power and all other supplies required to execute the borings to the required depths by the procedure described. Prior to mobilization, the Contractor shall submit to the Engineer for approval a list of equipment he will use.

c) Additional Equipment. If it appears during the course of the work that the Contractor will not complete the contract work within the specified contract period, he shall be required to obtain additional equipment, as deemed adequate by the Engineer, to insure completion of the work as specified. When the Contractor is ordered by the Engineer to use additional equipment or rigs to complete the work on schedule, he shall employ the most expeditious measures and act with the utmost promptness to comply with the Engineer's instructions.

d) Advancing and/or Cleaning the Drill Hole. Samples taken above the water table shall be taken from a dry hole. Advancing and/or cleaning the dry hole to the sampling depth shall be accomplished using a clean out auger or approved equivalent so as to keep the hole dry and

not disturb the virgin material at the depth to be sampled. Below the water table any method of cleaning the hole to the sampling depth that does not disturb the virgin material shall be used. If jetting is used, upward or baffled jets shall be required. Below the water table, a head of water greater or equal to the water table, shall be kept in the boring at all times, including the duration of the withdrawal of tools. Where seepage tests or double tube core barrel has introduced water into the hole above the water table, methods other than those required in a dry hole may be used at the convenience of the Contractor where approved by the Engineer. When core drilling through a boulder or ledge rock has been accomplished the cored portion of the hole shall be reamed out as required to advance the casing. If blasting is done, the Contractor shall obtain all necessary permits and shall comply with all laws, rules, regulations and ordinances governing blasting operations. Recirculated or clean water shall be used in overburden below the water table, in holes where seepage tests are designated or requested, and in rock coring. The holes shall be flushed out with clean water prior to testing in accordance with the appropriate technical provision.

The Contractor shall be responsible for keeping the hole open at all times during the drilling and until all tests or other work in connection with the hole has been completed and the Contractor has been authorized by the Engineer to backfill the hole or to provide the hole with piezometer. In the event of collapse of the hole prior to receipt of authorization to backfill, the hole shall be reopened, in a manner specified by the Engineer, at the Contractor's expense.

e) Artesian Flow. Artesian flow may be encountered when drilling. Each time such flow is encountered, the advancement of the bore hole shall be immediately interrupted and the artesian rise in water or pressure in the casing measured.

f) Advancing the Casing. The casing shall be advanced by hammer, rotary drill, or any method approved by the Engineer, in such a manner to keep the hole open, and insure a tight seal in sound rock. The casing shall be advanced at a sufficient distance behind the sampling operation so as not to disturb the material to be sampled.

9 SAMPLING AND CORING IN BORINGS

a) General. Samples (including Shelby tubes) and cores shall be taken at designated elevations and/or continuously (as directed by the Engineer), with the designated sampler or core barrel as directed by the Engineer. The hole shall be properly advanced and cleaned in accordance with Subparagraph 7-H-d, Advancing and/or Cleaning Drill Hole, prior to sampling. Sampling shall be done by such means as to prevent the inclusion of wash in the sampler. The depths of starting and stopping drives or runs shall be accurately established to the nearest 10 cm.

b) Coring in Overburden. Where specifically requested by the Engineer, double tube core barrels with or without liners will be used to core overburden, generally in dense materials, boulders, and highly weathered rock. The speed of rotation, rate of hydraulic advance, and length of run shall be adjusted so as to provide minimum soil disturbance and maximum recovery. The speed of rotation shall not exceed 200 RPM unless otherwise approved by the Engineer and the maximum length of run shall be such as to provide a 150 cm long sample within the liner, when approved by the Engineer.

c) Rock Core Drilling. The casing through overburden or weathered rock shall be sealed tightly in sound rock prior to commencement of rock coring. The coring of rock with double tube core barrels 101 mm shall be in accordance with Subparagraph b, except that the maximum length of run may be increased to 3 meters when approved by the Engineer. The Contractor shall exercise particular care in recording water losses, rod jerks, and other unusual coring experiences that, supplementing the core record, will indicate the nature and the extent of any fracturing.

10 CASING

a) General. The advancing of casing shall be as mentioned in Subparagraph 7-H-f.

b) Removal of Casing. Except as otherwise authorized by the Engineer, all casing shall be removed on completion of the work, and it shall remain the property of the Contractor. Casing shall not be removed until authorized by the Engineer.

11 TEST PITS

a) General. A test pit shall be any excavation in soil, cinders, hardpan, decomposed rock or other unconsolidated or partially consolidated overburden which has an open cross-sectional area large enough to permit safe, efficient engineering inspection in situ density testing and undisturbed bag sampling. Bag samples totaling 450 kg or more may be required. The Contractor shall comply with all safety regulations governing this work.

b) Equipment and Supplies. The Contractor shall furnish all equipment and supplies necessary to perform the work.

c) Excavation. The test pits shall be excavated to the required depths under dry (dewatered/unwatered) conditions.

d) Sampling. All sampling shall be performed by the Contractor as requested by the Engineer and labeled and preserved as specified in 7-G and 7-M, respectively.

e) Barricades. Immediately upon completion of excavation operations for each pit the Contractor shall construct an enclosure guard around each pit, set back about 1 meter from the edge of the pit. The enclosure shall be constructed of materials selected by the Contractor. The enclosure shall be constructed in such a manner that no person or animal can fall into the test pit. Barricades will not be measured for payment, and all costs in connection therewith shall be considered a subsidiary obligation of the Contractor. In addition, it is the Contractor's responsibility to ensure that the barricades are placed; the liability associated with the failure to do so shall lie with the Contractor.

f) Refilling of Test Pits and Test Trends. The test pits shall be refilled in compacted layers when directed by the Engineer. The refilling of test pits will not be measured for payment and all costs in connection therewith shall be considered a subsidiary obligation of the Contractor.

12 ABANDONED BORINGS AND FALSE STARTS

No measurement or payment will be made for borings abandoned or lost before reaching the required depths. Except with the specific permission of the Engineer, the Contractor shall not abandon or complete any boring, or remove any casing or drilling equipment, without first affording the Engineer the opportunity of obtaining the position and depth of the boring prior to abandonment or completion, and any other information which the Engineer may require. The Contractor shall furnish the Engineer with complete records and samples for the depth penetrated in the manner hereinafter prescribed for completed borings.

13 PRESERVING SAMPLES AND CORES

a) General. The Contractor shall provide all material, equipment and labor necessary for preserving soil samples and rock cores. Wax for sealing sample containers shall be Socony Vacuum Oil Company Product 2300, or approved equal. The preserving and storage of samples and cores shall be a subsidiary obligation of the Contractor in connection with obtaining the samples or cores and no extra payment shall be made for preservation or storage of samples and cores.

b) Test Pit Samples. Bulk samples selected by the Engineer from test pits shall be preserved in waterproof bags and shall be clearly marked with two (2) waterproof labels, one wired to the bag and one placed inside the bag. Jar samples taken as directed by the Engineer shall be scaled by double dipping the cap and threads into wax immediately after capping. Undisturbed samples requested by the Engineer shall be moisture proofed and handled accordingly and as requested by the Engineer.

c) Undisturbed Samples in Liners. After inspection by the Engineer, the ends of the sample tubes shall be cleaned out to a depth of 2 inches and a seal provided of micro crystalline wax, such as Socony Product 2300 or equal. A metal disc, having a diameter slightly less than the inner diameter of the tube shall be inserted into the wax at a distance of 2.5 cm from the end of the soil sample. The wax plug shall be flush with the ends of the tube and a metal cap shall be placed over the ends, taped and sealed with two coats of wax. Liners which are only partially full should be filled with wax before capping. Special care shall be made to mark the top and bottom of liner. Material taken from the shoe and the top shall be placed in separate litter jars and marked accordingly and sealed in accordance with the requirements of Subparagraph b.

d) Undisturbed Double Tube Core Samples Without Liners. After inspection by the Engineer, the undisturbed core sample shall be wrapped in polyethylene, coated with wax twice, and wrapped in cardboard, or other stiff material approved by the Engineer. Special care should be taken not to break or disturb the sample during the handling.

e) Soil and Rock Cores. All rock cores and all soil cores such as undisturbed samples shall be arranged neatly in the partitioned boxes constructed and marked in the same sequence in which they occurred before removal from the hole. Facing the open box with the hinged cover above the open box below, cores shall be arranged neatly in descending sequence beginning at the left end of the partition nearest the hinges and continuing in the other partitions from left to right. The highest core shall be placed in box 1 and the lowest portions of the core shall be placed in the other boxes in consecutive order. The runs shall be sectionalized by wood Spacers showing depth, length of run, fractures and their estimated width, and recovery. Core loss blocks shall be used to indicate areas in which no core is recovered. Core sections as designated by the Engineer, shall be wrapped in polyethylene sheets, coated with wax twice, and wrapped in cardboard or other stiff material approved by the Engineer.

14 STORAGE AND DELIVERY OF SAMPLES AND ROCK CORES

a) General. The Contractor shall be solely responsible for preserving all samples in good condition. He shall keep samples from undue exposure to the weather. The Contractor shall keep all descriptive labels and designations on sample jars and boxes clean and legible until final acceptance by the Engineer. The Contractor shall comply with all requests of the Engineer concerning the care and protection of samples.

b) Storage. Upon completion of drilling and sampling operations in each hole, or as necessary to protect samples, all boxes containing samples and cores shall be delivered to a structure provided by the Contractor near the work site. Undisturbed samples shall be transported with the tubes in a vertical position, top down, to prevent consolidation and segregation of pore water. Boxes containing disturbed samples and core boxes shall be so arranged in the storage area that the samples and cores can be conveniently and readily examined by the Engineer. Undisturbed samples shall also be stored in an orderly method. Upon request of the Engineer, the Contractor shall furnish a laborer to assist the Engineer in inspecting the samples and cores. The Contractor shall provide all transportation and labor required for storage of the samples and cores at the desired location.

c) Shipment of Selected Samples. Upon request by the Engineer, soil samples and cores shall be boxed by the Contractor as described below and shipped to the Laboratory approved by the Engineer. Samples not directed to be shipped to the above address shall remain at the core storage area at the site. Every precaution shall be taken to avoid damage to samples and cores, especially to undisturbed samples, as a result of careless handling and undue delay in shipping. Undisturbed samples shall be shipped in partitioned wooden boxes made from lumber 6cm, or heavier lumber. The sample tube shall be placed vertically top down, in the box and well-packed in excelsior or other equal material to protect the sample against vibration. The undisturbed sample and core boxes shall be marked "Do Not Jar or Vibrate" and "Handle, Haul and Ship in a Vertical Position". Containers containing glass jars shall be marked as such.

15 SEEPAGE TESTS

a) General. Seepage tests shall be performed in bore holes and at depths designated by the Engineer. Prior to performing the seepage tests, the bore hole shall be cleaned out and flushed with clean water to the bottom of the hole by means of a shielded jet or deflected jet as approved by the Engineer, so that all material is removed from inside the bore hole and a clean surface of undisturbed material exists at the bottom of the hole. The rate of seepage shall be determined by one of two methods described below. After performing the above tests, the bore hole may be advanced without advancing casing, cleaned as described above and the rate of seepage again determined. Ground water table shall be determined for each seepage test. The data to be recorded for each test which are common to each of the two test methods are as follows:

1. Inside diameter of casing.
2. Height of top of casing above ground surface.
3. Length of casing during test.
4. Diameter of bore hole below casing.
5. Depth to bottom of boring from top of casing.
6. Depth to standing water level from top of casing.
7. Description of exposed material tested.

b) Falling Water Level Method. The casing shall be filled with water and the rate of drop in the water level in the casing determined by observing the depth of the water surface below the top of the casing at 1, 2 and 5 minutes after the start of the test, and at 5-minute intervals thereafter. The record of measurements shall include the depth of the water surface below the top of casing before and after filling of the casing, the time, and tile amount of the drop measured from the start of testing for each observation. Observations shall be continued until the rate of drop in water level becomes negligible or until stopped by the Engineer. If the drop-in water level, as described above, is too rapid to permit accurate observations to be made, then the method described below shall be used.

c) Constant Water Level. Water shall be added in accurately measured quantities by pouring from calibrated containers or by pumping through a water meter at a rate of flow sufficient to maintain a constant water level at or near the top of the casing for a period of not less than 20 minutes, until stopped by the Engineer. The record of measurements shall include the depth of the water surface below the top of casing before filling and during the test period, the length of time during which the water in the casing was maintained at constant level, and the amount of water necessary to be added to maintain the constant water level in the casing at 1, 2, and 5 minutes, and at 5 minute intervals thereafter, as directed by the Engineer.

16 PRESSURE TESTING IN ROCK

a) General. Pressure testing of weathered and sound rock shall be performed as directed. The apparatus used shall consist of a single pneumatic or mechanical expanding packer to seal off a section of the bore hole for testing. The packer and drill rods shall be calibrated to determine friction losses in the system. The length of the packer when expanded shall be about five (5) times the diameter of the hole. It is the Contractor's responsibility that the packers used are compatible with the size casing used in each borehole. Water lines shall be arranged so that water may be pumped below the packer. The system shall include a pressure gage, water meter, a manually adjusted automatic pressure relief valve, and a pressure pump. After each three (3) meter depth of hole is drilled, the packer shall be seated so that the entire three (3) meter length of hole can be pressure tested. Water under pressure shall be pumped into the test section and the readings recorded. Upon completion of the test, the packer shall be removed, the hole drilled deeper, and the packer reinserted after an additional three (3) meters of hole have been drilled. The packer shall be seated each time at an elevation that will allow the full three (3) meter length of newly drilled hole to be tested.

b) Water Pressures, Duration of Tests, Data to be Recorded The pressure testing shall be performed in five (5) steps for each complete pressure test with the maximum pressure (P3) based upon the vertical depth to the mid-point of the test section. The value of P3 will be determined by the Engineer but will be in the range of 0.35 to 10 Kg/cm². In no case will the pressure at the test section exceed 0.23 Kg/cm2 per meter of depth. The following table shows "specified ratios" of pressure and times specified for each step of pressure test.

Step No.	Pressure (P)	Time(minutes)
1	$P_1 = 1/3\ P_3$	5
2	$P_2 = 2/3\ P_3$	5
3	P_3 (determined by test depth)	10
4	$P4 = 2/3\ P_3$	5
5	$P5 = 1/3\ P_3$	5

Additional data to be recorded in each test are as follows:

1. Elevation of bottom of hole at time of each test.
2. Elevation of packer.
3. Elevation of ground water table at the time of the test.
4. Elevation of piezometric level in artesian strata.
5. Length of test section.
6. Radius of hole.
7. Length of packer.
8. Height of pressure gauge above ground surface.

17 ARTESIAN MEASUREMENTS

a) General. Where artesian flow is encountered the Contractor shall measure its pressure as directed by the Engineer.

b) Equipment. The Contractor shall supply all necessary equipment for performing these measurements, including two Bourbon Gages, a watertight casing cap with "Y" connection

and bleeder valve, and expansion plugs to seal off a portion of the hole for testing. The expansion plugs shall be expandable rubber packer having a length about 5 times the diameter of the hole. The Bourbon Gages shall be calibrated in meters of water relative to atmospheric pressure. One gage shall have a range of 0 to 6 meters and the other a range of 0 to 30 meters.

c) Procedure. Where the artesian pressure is of such magnitude that the water in the borehole does not rise above the top of the casing, the pressure shall be measured and recorded as the number of meters and tenths of a meter between the natural ground water level and the level of the water in the casing. Where the artesian pressure is of such a magnitude that the water rises above the highest elevation to which the casing can be practicably extended, the pressure shall be measured by means of a Bourbon Gage fitted to a watertight casing cap by means of a "Y" connection equipped with a bleeder valve.

After each measurement of artesian pressure, the bottom of the borehole shall be advanced at least 0.3 meters but not more than 1.5 meters below the elevation at which the artesian pressure is encountered. If the artisan condition persists after advancing and cleaning out the borehole, additional measurements shall be made.

Records shall be kept of the gage readings and the vertical distances in meters and tenths of meters between the center of the gage, the natural ground surface and the natural ground water level.

18 SURVEYING AND HOLE MARKERS

Upon completion, each test boring, test pit, and well shall be surveyed to determine its exact location and elevation. A piece of plastic pipe filled with neat cement shall be installed by the Contractor to mark the hole. A suitable rust proof metal tag shall be attached to each marker showing the whole number, depth, and surface elevation. No separate payment will be made for whole markers, and all costs in connection therewith shall be considered a subsidiary obligation of the Contractor.

19 LABORATORY TESTING OF SOIL SAMPLES AND ROCK CORES

a) General. Laboratory testing will be completed on disturbed and undisturbed samples of soil and on lengths of rock core selected by the Engineer and shipped to a laboratory proposed by the Contractor and approved by the Engineer, as described in subparagraph 7-N, Storage and Delivery of Samples and Rock Cores.

b) Testing Laboratory. The laboratory testing shall be performed by an approved laboratory.

c) Type and Approximate Number of Tests. The complete laboratory testing program cannot be determined until the field exploration has been completed and the number and condition of all the samples known. The lab testing program (including Odometer, Triaxial and etc.) shall be as directed and preapproved by the Engineer.

d) Submittal of a final report. A written detailed report containing the results of the laboratory testing program shall be submitted following the completion of the work in 5 copies to the Engineer for review, then the Contractor will issue the finalized report (5 copies also). The report should identify also the soil strata of the site. The report shall contain the summary of the results and the procedures used. The report shall contain the results of the field testing and the summary of the results as well as the results of the laboratory tests and all engineering analysis (as directed by the Engineer, including slope stability and shoring system) and conclusions / recommendations for each and every project specific structure.

SECTION 02400
PARTICULAR SPECIFICATIONS FOR DEEP DYNAMIC COMPACTION

Note: In the event of any contradiction, conflict or inconsistency between this Particular Specifications and the other parts of the Technical Specifications, the provisions and terms of this Particular Specifications shall prevail.

1 PARTICULAR SPECIFICATIONS FOR DEEP DYNAMIC COMPACTION WORKS – AREA PHASE 1 (20,396M2)

1.1 Introduction

The Area Phase 1 is represented by the Boreholes BH1 and BH2.

BH1 at elevation +2.6

0-1.5m:

Loose to medium dense (according to penetration rates) partially saturated/submerged Manmade Fill (Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders),

1.5-9m:

Gravely very Silty medium dense to dense (according to corrected SPT and/or DCPT values for the increase resistance due to negative excess pore water pressure set up during the testing) fully saturated/submerged poorly graded fine SAND of intermediate plasticity,

9-18m:

Beige highly weathered crushed and closely fractured weak to moderately strong medium to coarse grained vuggy Calcareous SANDSTONE / very Sandy LIMESTONE (very poor to poor rockmass according to RMR)

BH2 at elevation +1.5

0-3m:

Loose to medium dense (according to penetration rates) partially saturated/submerged Manmade Fill (Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders),

3-10m:

Gravely very Silty medium dense to dense (according to penetration rates) fully saturated/submerged poorly graded fine SAND of intermediate plasticity,

9-18m:

Beige highly weathered crushed and closely fractured weak to moderately strong medium to coarse grained vuggy Calcareous SANDSTONE / very Sandy LIMESTONE (very poor to poor rockmass/bedrock according to RMR)

Neither loose to medium dense Manmade Fill nor the multi-layered foundation soil (Manmade Fill and underlying Gravely very Silty medium dense to dense fine SAND) with water table (seawater) at bottom level of foundation, cannot be considered safe bearing strata for the Expansion and Upgrade of Al-Ghadir WWTP, accordingly; the multi-layered foundation soil shall be densified by Deep Dynamic Compaction from the elevation +2.00, and the type of foundation shall be enlarged-raft, taking the heterogeneous Manmade Fill (Type-S1 that is rarely used, Type-S2 that is mostly used and Type-S3 that is moderately used) into consideration.

1.2 Description of Work

The work shall consist of densifying the Manmade Fill (loose to medium dense partially saturated/submerged Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders, 2.25m thick in average and Favorable for Deep Dynamic Compaction (Zone 1) according to FHWA-SA-95-037, 1995) and underlying very Silty fine SAND of intermediate plasticity (medium dense to dense fully saturated / submerged, 7.25m thick in average and Intermediate for Deep Dynamic Compaction (Zone 2) according to FHWA-SA-95-037, 1995) by Deep Dynamic Compaction (DDC) to the area and extent shown on the drawings (20,396m2) and to a depth of 9.5m from the elevation +2, prior to Expansion and Upgrade of Al-Ghadir WWTP.

The work shall be performed by a Specialty Contractor who can meet the requirements. The Specialty Contractor shall furnish all equipment (including but not limited to crawler cranes, pounders, impact rollers and seismograph) that are in good and safe working condition, labor and materials necessary or incidental to the completion of the DDC for this project.

1.3 Description of Deep Dynamic Compaction

The DDC is a process whereby a heavy tamper is repeatedly raised and dropped from a specified height to impact onto the ground surface, thereby transmitting high compaction energy into the soil mass. The tamper shall be raised and dropped by a single cable with a free spool hoisting drum (80% efficiency). The depth of improvement depends upon the tonnage of the weight, the height of the fall and the amount of energy applied per unit area.

The tamper weight shall be constructed to resist the high impact stresses. The high energy compaction (Phase 1) shall be applied in Three (3) passes which is designated on the drawings as the 1st pass (8 nos. of drops at each grid-point), 2nd pass (8 nos. of drops at each grid-point) and 3rd pass (5 nos. of drops at each grid-point) locations. After energy application at any 1st pass location, there shall be a minimum waiting period of three days before energy application at 2nd pass location, to allow the excess pore water pressure to dissipate between the passes. The high energy compaction consists of dropping the tamper (25ton) from a height of 25m to impact the surface on a grid pattern of 6m by 6m. The pass is described as either of the following, whichever occurs first:

- The application of all the specified drops at a grid-point location, or
- Whenever the crater depth reaches 1.5 to 2m regardless of the number of drops at a grid-point location.

After each drop, craters created by the tampers (shallower than 1.5 to 2m) shall be backfilled and graded with quarry runs Engineering Fill - 0/304.8mm (A-1-a with fines up to 15%) before the next drop is applied.

The Engineering Fill - 0/304.8mm shall be well graded (coefficient of curvature between 1 and 3), and shall have a minimum 4-days soaked CBR of 45% at 95% proctor density.

The Engineering Fill - 0/304.8mm shall be tested as follows, and shall be approved by the Engineer prior to start backfilling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,

- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 95% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The Engineering Fill - 0/304.8mm shall also be tested as mentioned-above during the execution for every 7,000m^2 compacted with high energy (or at least once for a section less than 7,000m^2), and the lab test results shall be submitted to the Engineer for his approval.

After the 3rd pass of high energy compaction (Phase 1) has been completed, the ground surface shall be levelled and a low energy compaction called ironing phase shall be applied in Two (2) passes which is designated on the drawings as the 1st pass (5 nos. of drops at each grid-point) and 2nd pass (4 nos. of drops at each grid-point). The ironing pass consists of dropping the tamper (10ton) from a height of 3m to impact the surface with continuous overlapping.

The impact rolling then final leveling (leveling course) and after that smooth rolling shall follow the ironing phase. The impact rolling (at least 8 nos. of passes) shall be done by using impact rollers (12-ton class and 25 Kilojoules of potential energy, each) with 3-sided non-circular steel drum running at a speed of 9kph, and the smooth rolling (at least 6 nos. of passes and/or until reaching >=96% of proctor density) shall be done by using 15-ton class single-drum vibratory smooth rollers. At least 2 nos. of impact and 2 nos. of smooth rollers shall be provided by the Contractor.

The quarry runs Leveling Course - 0/101.6mm (A-1-a with fines up to 10%) shall be well graded (coefficient of curvature between 1 and 3), and shall have a minimum 4-days soaked CBR of 60% at 96% proctor density. The Leveling Course shall be placed in compacted (>= 96% of proctor density) layers of 20cm thick each with respect to its maximum and nominal maximum aggregate sizes of 10 1.6mm and 76.2mm (respectively).

The Leveling Course - 0/101.6mm shall be tested as follows, and shall be approved by the Engineer prior to start leveling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 96% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The Leveling Course - 0/101.6mm shall also be tested as mentioned-above during the execution for every 7,000m^2 leveled and compacted by using smooth roller (or at least once for a section less than 7,000m^2), and the lab test results (including Field Density for every 2000m^2) shall be submitted to the Engineer for his approval.

1.4 Deep Dynamic Compaction Equipment

The Contractor shall provide the equipment capable of raising (up to 33.5m) and dropping tampers (up to 32 tons) on a repeated basis without a significant amount of down time. The Contractor shall also provide equipment to backfill and grade the craters created by the tampers after each drop.

The Contractor shall provide a minimum of One (1) crawler crane (>=150 tons with cable size of >= 38mm) and One (1) set of tampers (25 tons octagonal and 10 tons square, both with base area of 3m2) for the high and low energy compaction. The contact pressure which is the weight of tamper divided by the base area shall be in the range of 33 to 83kPa.

The Contractor shall stake (with wood lathe or wire markers with flags) all of the grid-point locations as shown on drawings. The tamper shall be dropped with the staking accurate to the nearest +/- 0.3m. Following each pass, the stakes or wire markers with flags shall be replaced for the next pass.

1.5 Site Preparation

The high- and low-level areas shall be cut and filled (respectively) to elevation +2.00, and filling the low-level areas shall be done by using the granular materials resulted from cut and imported A-2-5 to A-2-6 material with Cobbles (more or less 18%) and Boulders (more or less 8%). The imported A-2-5 to A-2-6 material (0/304.8mm) shall have a minimum 4-days soaked CBR of 20% at 95% proctor density.

The imported A-2-5 to A-2-6 material (0/304.8mm) shall be placed in semi-compacted (more or less 92% of proctor density) layers of 45cm thick each with respect to its maximum and nominal maximum aggregate sizes of 304.8mm and 203.2mm (respectively). The granular material resulted from cut shall also be semi-compacted.

The imported A-2-5 to A-2-6 material shall be tested as follows, and shall be approved by the Engineer prior to start filling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 96% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The imported A-2-5 to A-2-6 material shall also be tested as mentioned-above during the execution for every 7,000m2 filled and semi-compacted by using smooth roller without vibration (or at least once for a section less than 7,000m^2), and the lab test results (including Field Density for every 2000m^2) shall be submitted to the Engineer for his approval.

As for the cut, the sharp vertical drops shall be flattened to provide access for the crawler crane for lifting and dropping of the tampers. The small hills or stockpiles of miscellaneous material should be smoothed out and bladed to a more nearly level surface at elevation +2.00

A seismograph shall be used to measure the magnitude of ground vibrations being transmitted off-site. The Particle Velocity (at frequency of 6 to 10 hertz) shall be less than 19mm/sec during the DDC, accordingly; the overall DDC area shall be surrounded by a 3m deep and 0.6m wide trench as a ground-vibration barrier within a setback of 6m, to minimize the effect of ground-vibration and lateral soil-mass displacement on neighboring structures (such as the side-slopes of landfill cells and airport's runway).

An open trench is the most effective in reducing vibrations, however; open trench is concern for side-slope stability of landfill cells and airport's runway. Accordingly, the open trench shall be backfilled with loosely placed (dumped) compressible material resulted from excavation of the trench.

1.6 Deep Dynamic Compaction Sequence

The total area for high energy compaction (Phase 1) can be divided into smaller work sections (such as 72m by 72m) with one section completed before another section is started, however; the low energy compaction (ironing phase) and impact rolling as well as final leveling and smooth rolling shall be applied to overall DDC area (20,396m^2).

Based on previous experience Lukas (FHWA-SA-95-037, 1995) recommends a maximum depth of improvement (d max) that can be achieved, given by:

d max = n (WH)^0.5

Where W is the tamper weight in tones, and H is the height of drop in m. The value of n depends on soil type, and decreases with an increase in degree of saturation.

Phase 1: High Energy Compaction with 3 nos. of passes on a grid pattern of 6m by 6m (see below Figure 1).

- 1st Pass (8 nos. of drops at each grid-point location), for W=25ton and H=25m;

  Energy per drop=25ton*9.807*25m=6.1MJ, and

  d max=0.4(25*25) ^0.5=10m > 9.5m,

- 2nd Pass (8 nos. of drops at each grid-point location), for W=25ton and H=25m;

  Energy per drop=25ton*9.807*25m=6.1MJ, and

  d max=0.4(25*25) ^0.5=10m > 9.5m,

- 3rd Pass (5 nos. of drops at each grid-point location), for W=25ton and H=25m;

Energy per drop=25ton*9.807*25m=6.1MJ, and

d max=0.4(25*25) ^0.5=10m > 9.5m,

Unit Applied Energy (kJ/m^3) =(N*W*H*P)/Grid Spacing^2, where N: Average Number of drop and P: Number of Passes,

Unit Applied Energy=(7*25ton*25m*3)/6^2=365kJ/m^3*0.8 (80% efficiency) =292kJ/m^3,

250kJ/m3<292kJ/m^3<350kJ/m^3 for semipervious fully saturated / submerged very Silty fine SAND (Zone 2), CONFIRMED with a Total Applied Energy of 2,774kJ/m^2 (292kJ/m3*9.5m)

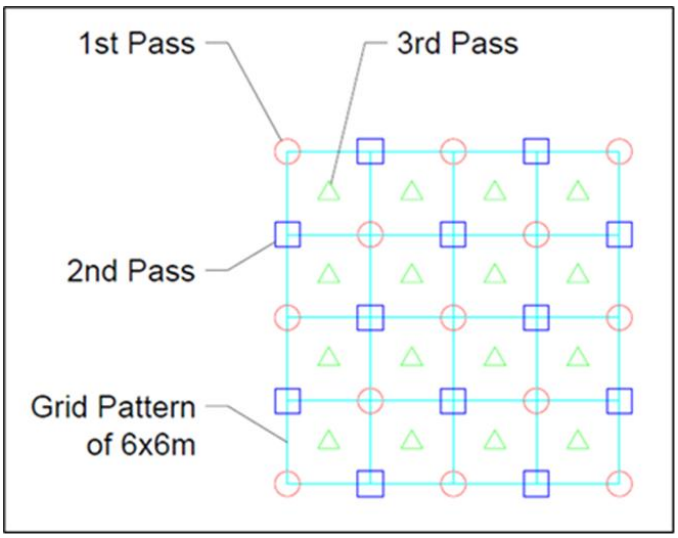


Figure 1

Low Energy Compaction: Ironing phase with 2 nos. of passes.

- 1st ironing pass with continuous overlapping (5 nos. of drops), for W=10tons and H=3m;

  Energy per drop=10ton*9.807*3m=0.3MJ, and

  d max=0.5(10*3)^0.5=2.7m > 2.25,

- 2nd ironing pass with continuous overlapping (4 nos. of drops), for W=10tons and H=3m;

  Energy per drop=10ton*9.807*3m=0.3MJ, and

  d max=0.5(10*3)^0.5=2.7m > 2.25,

  Unit Applied Energy (kJ/m^3)=(N*W*H*P)/Grid Spacing^2, where N: Average Number of drop and P: Number of Passes,

  Unit Applied Energy=(4.5*10ton*3m*2)/1^2=270kJ/m^3*0.8 (80% efficiency) =216kJ/m^3,

  200kJ/m^3<216kJ/m^3<250kJ/m^3 for Pervious partially saturated / submerged Manmade Fill (Zone 1), CONFIRMED with a Total Applied Energy of 486kJ/m^2 (216kJ/m^3*2.25m)

Impact Rolling:

- The impact rolling (at least 8 nos. of passes) shall be done by using impact rollers (12-ton class and 25 Kilojoules of potential energy, each) with 3-sided non-circular steel drum running at a speed of 9kph.

Final Leveling and Smooth Rolling:

- The smooth rolling (at least 6 nos. of passes and/or until reaching >=96% of proctor density) shall be done by using 15-ton class single-drum vibratory smooth rollers.15-ton class single-drum vibratory smooth-roller, at least 6 nos. of passes (>=98% of Proctor Density).

1.7 Additional Works

If the desired improvement (having dense to very dense Manmade Fill and underlying gravely very silty fine SAND that is called multi-layered foundation soil) has not been achieved upon completion of Deep Dynamic Compaction; additional energy could be applied, to result in greater ground improvement. This additional work will be paid at unit rate for Deep Dynamic Compaction (Phase 1 including backfilling and grading the craters, ironing phase and impact rolling).

1.8 Monitoring

The Deep Dynamic Compaction (DDC) operations shall be monitored. The monitoring shall include, but not be limited to observations of crater depths, monitoring ground-vibrations by using seismograph, determining the heave adjacent to craters that is a sign of excess porewater pressure and measuring the surface settlement on grid basis before and after DDC (before final leveling and smooth rolling) as requested by the Engineer.

The Contractor shall also be responsible for counting the number of drops at each grid-point location to be sure that the proper energy is applied. If any additional drops are requested by the Engineer, these shall also be recorded by the Contractor.

1.9 Verification Tests

The verification tests (Pressiometer and Static Cone Penetration) shall be executed before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling), taking the multi-layered foundation soil improvement with additional time (due to dissipation of the excess porewater pressure) into consideration, to determine the depth and degree of improvement.

Pressiometer Test (PMT) in Manmade Fill:

The precored (T2 76) Pressiometer test in Manmade Fill shall be performed (according to ASTM D4719) at 2m intervals by using Menard type volume displacement tricell probe 74mm in outside diameter with maximum working pressure of 10Mpa.

The Pressiometer test shall be performed, to obtain Menard Limit Pressure and Pressiometer Modulus. To obtain viable test results; disturbance to the borehole-wall shall be minimized, and in case of having difficulties to form a satisfactory pocket, the probe shall be driven into the precored hole with thin wall slotted steel casing.

One (1) borehole for every 7,000m^2 shall be cored (in Manmade Fill, and according to ASTM D6640) to a depth of 4m / to a depth of reaching the Gravely very Silty fine SAND (seabed sediments) before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling). The core descriptions shall be according to BS 5930 - Section 8.

Perforated (one third of the standpipe) uPVC pressure pipes (according to ASTM D1785), 73mm in OD and 5.2mm thick, wrapped with geotextile (PP, 150 gr/m^2) shall be installed into the boreholes as open standpipe-piezometer (and a casing for the Static Cone Penetration Test that will be executed in the same location) with concrete heading (the number of the borehole, its depth and elevation shall permanently be written on concrete head) and steel pipe protection, to measure the depth and fluctuations of the groundwater table after air lifting.

Static Cone Penetration Test with Pore Pressure Measurement (CPTu / Piezocone Sounding) in Seabed Sediments:

A cone with electrical sensors shall be driven into Gravely very Silty fine SAND (seabed sediments) at a standard rate of penetration 2cm per second.

One (1) CPTu sounding for every 7,000m^2 shall be performed (in Manmade Fill, and according to ASTM D5778) to a depth of 15.5m (14m + 1.5m) / to a depth of cone refusal (50MPa) / to a depth of reaching the bedrock (Calcareous SANDSTONE / very Sandy LIMESTONE) from the seabed-level, before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling). The cone shall be equipped with friction reducer (if needed / where needed), to improve the depth of penetration.

A truck (reaction frame of 25 tons) mounted trust mechanism of GEOMIL (or equivalent having pushing and pulling forces of >= 200kN and >=150kN, respectively) with cone data acquisition system shall be used in CPTu.

The truck mounted trust mechanism shall be setup by using hydraulic pistons, to obtain a trust direction as near as possible to the vertical. The non-verticality of the sounding shall continuously be measured with slope sensors, to avoid breaking the push rods.

The continuously measured analogue data (cone resistance, sleeve friction, friction ratio and dynamic pore pressure) shall be converted to the digital form at 25mm intervals. Zero load readings of all sensors (reference measurements) shall be recorded at the start and end of each CPTu sounding. Calibrations shall be carried out at regular intervals based on the stability of the zero load readings with functional checks during the work.

Semi-empirical correlations will be used to estimate the following geo-mechanical parameters (CPTu interpretations).

- Soil profile (normalized/non-normalized soil behavior type),
- Equivalent SPT N60 profile,
- Soil unit weight,
- Undrained shear strength,
- Soil sensitivity,
- Undrained shear strength ratio,
- Over consolidation ratio,
- In-situ stress ratio,
- Friction angle,
- Relative density,
- Stiffness and modulus,
- Hydraulic conductivity,
- Consolidation characteristics (coefficient of consolidation), and
- Constrained modulus (estimating the consolidation settlement).

All above-mentioned works shall be executed as directed by the Engineer, and the Engineer shall be provided by the Contractor with verification test reports for his approval.

1.10 Safety Program

A detailed safety program will be required to provide protection for job site personnel / off-site personnel and adjacent properties. This safety program should be submitted prior to commencement of the work for review and approval by the Engineer.

The safety program should include required setback distances from the point of impact from the weight for personnel so that they are not within range of flying particles that may occur from impact of the weight into the ground. It should also include the manner in which the cable is attached to the tamper and the frequency of safety checks on the cable and associated equipment to prevent failure during DDC operations.

Photographs should also be made of nearby structures / adjacent properties that might be affected by the DDC operations and included with the safety plan submittal. All items associated with the safety program shall not be paid for separately, but shall be included in the cost of the DDC operations.

1.11 Records

The Contractor shall keep accurate records of the DDC operations, i.e., the locations where the drops have been made, the number of drops per grid-pattern location, depth of crater penetration, amount of

Engineering Fill - 0/304.8mm used in backfilling the craters, the pass number, ground surface elevations following each pass, and these results shall be available in the Contractor's site office on a daily basis. On a weekly basis, this information shall be submitted to the Engineer for his approval.

Any circumstances affecting the work or intended improvement as a result of DDC should be brought to the attention of the Engineer.

1.12 Final Report

A final report giving full description of site, site preparation, DDC equipment, DDC works (including monitoring), additional works (if any) and results of verification tests (including depth and degree of improvement) shall be prepared and submitted to the Engineer for his approval as One (1) soft and Three (3) hard copies.

The report shall include (but not limited to):

- Current topography,
- As-built drawings (Plans and Sections),
- Weekly records,
- Site photos,
- Engineering analysis as requested by the Engineer, and
- Conclusions / recommendations.

2 PARTICULAR SPECIFICATIONS FOR DEEP DYNAMIC COMPACTION WORKS – AREA PHASE 2A (39,462M^2)

2.1 Introduction

The Area Phase 2a is represented by the Boreholes BH2 and BH3.

BH2 at elevation +1.5

0-3m:

Loose to medium dense (according to penetration rates) partially saturated/submerged Manmade Fill (Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders),

3-10m:

Gravely very Silty medium dense to dense (according to penetration rates) fully saturated/submerged poorly graded fine SAND of intermediate plasticity,

9-18m:

Beige highly weathered crushed and closely fractured weak to moderately strong medium to coarse grained vuggy Calcareous SANDSTONE / very Sandy LIMESTONE (very poor to poor rockmass/bedrock according to RMR)

BH3 at elevation +1

0-4m:

Loose to medium dense (according to penetration rate) partially saturated/submerged Manmade Fill (Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders),

4-18m:

Gravely very Silty medium dense to dense (according to corrected SPT and/or DCPT values for the increase resistance due to negative excess pore water pressure set up during the testing) fully saturated/submerged poorly graded fine SAND of intermediate plasticity.

Neither loose to medium dense Manmade Fill nor the multi-layered foundation soil (Manmade Fill and underlying Gravely very Silty medium dense to dense fine SAND) with water table (seawater) at bottom level of foundation, cannot be considered safe bearing strata for the Expansion and Upgrade of Al-Ghadir WWTP, accordingly; the multi-layered foundation soil shall be densified by Deep Dynamic Compaction from the elevation +2.00, and the type of foundation shall be enlarged-raft, taking the heterogeneous Manmade Fill (Type-S1 that is rarely used, Type-S2 that is mostly used and Type-S3 that is moderately used) into consideration.

2.2 Description of Work

The work shall consist of densifying the Manmade Fill (loose to medium dense partially saturated/submerged Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders, 4.25m (3.5m + 0.75m thick additional fill, to reach elevation +2) thick in average and Favorable for Deep Dynamic Compaction (Zone 1) according to FHWA-SA-95-037, 1995) and underlying very Silty fine SAND of intermediate plasticity (medium dense to dense fully saturated / submerged, >10.5m thick in average and Intermediate for Deep Dynamic Compaction (Zone 2) according to FHWA-SA-95-037, 1995) by Deep Dynamic Compaction (DDC) to the area and extent shown on the drawings (39,462m^2) and to a depth of 14.75m from the elevation +2, prior to Expansion and Upgrade of Al-Ghadir WWTP.

The work shall be performed by a Specialty Contractor who can meet the requirements. The Specialty Contractor shall furnish all equipment (including but not limited to crawler cranes, pounders, impact rollers and seismograph) that are in good and safe working condition, labor and materials necessary or incidental to the completion of the DDC for this project.

2.3 Description of Deep Dynamic Compaction

The DDC is a process whereby a heavy tamper is repeatedly raised and dropped from a specified height to impact onto the ground surface, thereby transmitting high compaction energy into the soil mass. The tamper shall be raised and dropped by a single cable with a free spool hoisting drum (80% efficiency). The depth of improvement depends upon the tonnage of the weight, the height of the fall and the amount of energy applied per unit area.

The tamper weight shall be constructed to resist the high impact stresses. The high energy compaction (Phase 1) shall be applied in Three (3) passes which is designated on the drawings as the 1st pass (5 nos. of drops at each grid-point), 2nd pass (5 nos. of drops at each grid-point) and 3rd pass (4 nos. of drops at each grid-point) locations. After energy application at any 1st pass location, there shall be a minimum waiting period of three days before energy application at 2nd pass location, to allow the excess pore water pressure to dissipate between the passes. The high energy compaction consists of dropping the tamper (32ton) from a height of 33.5m to impact the surface on a grid pattern of 6m by 6m. The pass is described as either of the following, whichever occurs first:

- The application of all the specified drops at a grid-point location, or
- Whenever the crater depth reaches 1.5 to 2m regardless of the number of drops at a grid-point location.

After each drop, craters created by the tampers (shallower than 1.5 to 2m) shall be backfilled and graded with quarry runs Engineering Fill - 0/304.8mm (A-1-a with fines up to 15%) before the next drop is applied.

The Engineering Fill - 0/304.8mm shall be well graded (coefficient of curvature between 1 and 3), and shall have a minimum 4-days soaked CBR of 45% at 95% proctor density.

The Engineering Fill - 0/304.8mm shall be tested as follows, and shall be approved by the Engineer prior to start backfilling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 95% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The Engineering Fill - 0/304.8mm shall also be tested as mentioned-above during the execution for every 7,000m2 compacted with high energy (or at least once for a section less than 7,000m^2), and the lab test results shall be submitted to the Engineer for his approval.

After the 3rd pass of high energy compaction (Phase 1) has been completed, the ground surface shall be levelled and a low energy compaction called ironing phase shall be applied in Two (2) passes which is designated on the drawings as the 1st pass (2 nos. of drops at each grid-point) and 2nd pass (2 nos. of drops at each grid-point). The ironing pass consists of dropping the tamper (15ton) from a height of 5m to impact the surface with continuous overlapping.

The impact rolling then final leveling (leveling course) and after that smooth rolling shall follow the ironing phase. The impact rolling (at least 12 nos. of passes) shall be done by using impact rollers (12-ton class and 25 Kilojoules of potential energy, each) with 3-sided non-circular steel drum running at a speed of 9kph, and the smooth rolling (at least 6 nos. of passes and/or until reaching >=96% of proctor density) shall be done by using 15-ton class single-drum vibratory smooth rollers. At least 2 nos. of impact and 2 nos. of smooth rollers shall be provided by the Contractor.

The quarry runs Leveling Course - 0/101.6mm (A-1-a with fines up to 10%) shall be well graded (coefficient of curvature between 1 and 3), and shall have a minimum 4-days soaked CBR of 60% at 96% proctor density. The Leveling Course shall be placed in compacted (>= 96% of proctor density) layers of 20cm thick each with respect to its maximum and nominal maximum aggregate sizes of 10 1.6mm and 76.2mm (respectively).

The Leveling Course - 0/101.6mm shall be tested as follows, and shall be approved by the Engineer prior to start leveling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),

- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 96% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The Leveling Course - 0/101.6mm shall also be tested as mentioned-above during the execution for every 7,000m^2 leveled and compacted by using smooth roller (or at least once for a section less than 7,000m2), and the lab test results (including Field Density for every 2000m^2) shall be submitted to the Engineer for his approval.

2.4 Deep Dynamic Compaction Equipment

The Contractor shall provide the equipment capable of raising (up to 33.5m) and dropping tampers (up to 32 tons) on a repeated basis without a significant amount of down time. The Contractor shall also provide equipment to backfill and grade the craters created by the tampers after each drop.

The Contractor shall provide a minimum of One (1) crawler crane (>=150 tons with cable size of >= 38mm) and One (1) set of tampers (32 tons octagonal and 15 tons square, both with base area of 4m2) for the high and low energy compaction. The contact pressure which is the weight of tamper divided by the base area shall be in the range of 37.5 to 80kPa.

The Contractor shall stake (with wood lathe or wire markers with flags) all of the grid-point locations as shown on drawings. The tamper shall be dropped with the staking accurate to the nearest +/- 0.3m. Following each pass, the stakes or wire markers with flags shall be replaced for the next pass.

2.5 Site Preparation

The high- and low-level areas shall be cut and filled (respectively) to elevation +2.00, and filling the low-level areas shall be done by using the granular materials resulted from cut and imported A-2-5 to A-2-6 material with Cobbles (more or less 18%) and Boulders (more or less 8%). The imported A-2-5 to A-2-6 material (0/304.8mm) shall have a minimum 4-days soaked CBR of 20% at 95% proctor density.

The imported A-2-5 to A-2-6 material (0/304.8mm) shall be placed in semi-compacted (more or less 92% of proctor density) layers of 45cm thick each with respect to its maximum and nominal maximum aggregate sizes of 304.8mm and 203.2mm (respectively). The granular material resulted from cut shall also be semi-compacted.

The imported A-2-5 to A-2-6 material shall be tested as follows, and shall be approved by the Engineer prior to start filling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,

- 4 days Soaked CBR at 96% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The imported A-2-5 to A-2-6 material shall also be tested as mentioned-above during the execution for every 7,000m^2 filled and semi-compacted by using smooth roller without vibration (or at least once for a section less than 7,000m^2), and the lab test results (including Field Density for every 2000m^2) shall be submitted to the Engineer for his approval

As for the cut, the sharp vertical drops shall be flattened to provide access for the crawler crane for lifting and dropping of the tampers. The small hills or stockpiles of miscellaneous material should be smoothed out and bladed to a more nearly level surface at elevation +2.00

A seismograph shall be used to measure the magnitude of ground vibrations being transmitted off-site. The Particle Velocity (at frequency of 6 to 10 hertz) shall be less than 19mm/sec during the DDC, accordingly; the overall DDC area shall be surrounded by a 3m deep and 0.6m wide trench as a ground-vibration barrier within a setback of 6m, to minimize the effect of ground-vibration and lateral soil-mass displacement on neighboring structures (such as the side-slopes of landfill cells and airport's runway).

An open trench is the most effective in reducing vibrations, however; open trench is concern for side-slope stability of landfill cells and airport's runway. Accordingly, the open trench shall be backfilled with loosely placed (dumped) compressible material resulted from excavation of the trench.

2.6 Deep Dynamic Compaction Sequence

The total area for high energy compaction (Phase 1) can be divided into smaller work sections (such as 72m by 72m) with one section completed before another section is started, however; the low energy compaction (ironing phase) and impact rolling as well as final leveling and smooth rolling shall be applied to overall DDC area (39,462m^2).

Based on previous experience Lukas (FHWA-SA-95-037, 1995) recommends a maximum depth of improvement (d max) that can be achieved, given by:

d max = n (WH)^0.5

Where W is the tamper weight in tones, and H is the height of drop in m. The value of n depends on soil type, and decreases with an increase in degree of saturation.

Phase 1: High Energy Compaction with 3 nos. of passes on a grid pattern of 6m by 6m (see below Figure 2).

- 1st Pass (5 nos. of drops at each grid-point location), for W=32ton and H=33.5m;

  Energy per drop=32ton*9.807*33.5m=10.5MJ, and

  d max=0.4(32*33.5) ^0.5=13m ~ 14.75m,

- 2nd Pass (5 nos. of drops at each grid-point location), for W=32ton and H=33.5m;

  Energy per drop=32ton*9.807*33.5m=10.5MJ, and

  d max=0.4(32*33.5) ^0.5=13m ~ 14.75m,

- 3rd Pass (4 nos. of drops at each grid-point location), for W=32ton and H=33.5m;

Energy per drop=32ton*9.807*33.5m=10.5MJ, and

d max=0.4(32*33.5) ^0.5=13m ~ 14.75m,

Unit Applied Energy (kJ/m3) =(N*W*H*P)/Grid Spacing^2, where N: Average Number of drop and P: Number of Passes,

Unit Applied Energy=(4.7*32ton*33.5m*3)/6^2=420kJ/m3*0.8 (80% efficiency) =336kJ/m^3,

250kJ/m^3<336kJ/m^3<350kJ/m^3 for semipervious fully saturated / submerged very Silty fine SAND (Zone 2), CONFIRMED with a Total Applied Energy of 4,368kJ/m^2 (336kJ/m^3*13m).

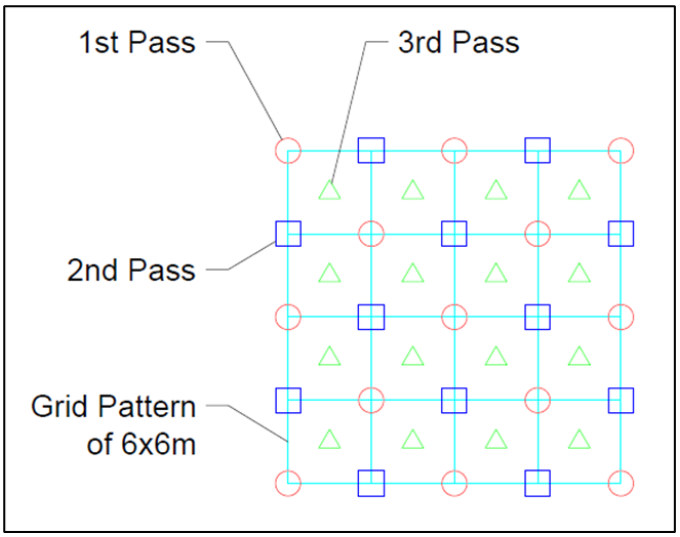


Figure 2

Low Energy Compaction: Ironing phase with 2 nos. of passes.

- 1st ironing pass with continuous overlapping (2 nos. of drops), for W=15tons and H=5m;

  Energy per drop=15ton*9.807*5m=0.7MJ, and

  d max=0.5(15*5) ^0.5=4.3m > 4.25,

- 2nd ironing pass with continuous overlapping (2 nos. of drops), for W=15tons and H=5m;

  Energy per drop=15ton*9.807*5m=0.7MJ, and

  d max=0.5(15*5) ^0.5=4.3m > 4.25,

Unit Applied Energy (kJ/m3) =(N*W*H*P)/Grid Spacing^2, where N: Average Number of drop and P: Number of Passes,

Unit Applied Energy=(2*15ton*5m*2)/1^2=300kJ/m^3*0.8 (80% efficiency) =240kJ/m^3,

200kJ/m^3<240kJ/m^3<250kJ/m^3 for Pervious partially saturated / submerged Manmade Fill (Zone 1), CONFIRMED with a Total Applied Energy of 1020kJ/m2 (240kJ/m3*4.25m)

Impact Rolling:

- The impact rolling (at least 12 nos. of passes) shall be done by using impact rollers (12-ton class and 25 Kilojoules of potential energy, each) with 3-sided non-circular steel drum running at a speed of 9kph.

Final Leveling and Smooth Rolling:

- The smooth rolling (at least 6 nos. of passes and/or until reaching >=96% of proctor density) shall be done by using 15-ton class single-drum vibratory smooth rollers.15-ton class single-drum vibratory smooth-roller, at least 6 nos. of passes (>=98% of Proctor Density).

2.7 Additional Works

If the desired improvement (having dense to very dense Manmade Fill and underlying gravely very silty fine SAND that is called multi-layered foundation soil) has not been achieved upon completion of Deep Dynamic Compaction; additional energy could be applied, to result in greater ground improvement. This additional work will be paid at unit rate for Deep Dynamic Compaction (Phase 1 including backfilling and grading the craters, ironing phase and impact rolling).

2.8 Monitoring

The Deep Dynamic Compaction (DDC) operations shall be monitored. The monitoring shall include, but not be limited to observations of crater depths, monitoring ground-vibrations by using seismograph, determining the heave adjacent to craters that is a sign of excess porewater pressure and measuring the surface settlement on grid basis before and after DDC (before final leveling and smooth rolling) as requested by the Engineer.

The Contractor shall also be responsible for counting the number of drops at each grid-point location to be sure that the proper energy is applied. If any additional drops are requested by the Engineer, these shall also be recorded by the Contractor.

2.9 Verification Tests

The verification tests (Pressiometer and Static Cone Penetration) shall be executed before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling), taking the multi-layered foundation soil improvement with additional time (due to dissipation of the excess porewater pressure) into consideration, to determine the depth and degree of improvement.

Pressiometer Test (PMT) in Manmade Fill:

The precored (T2 76) Pressiometer test in Manmade Fill shall be performed (according to ASTM D4719) at 2m intervals by using Menard type volume displacement tricell probe 74mm in outside diameter with maximum working pressure of 10Mpa.

The Pressiometer test shall be performed, to obtain Menard Limit Pressure and Pressiometer Modulus. To obtain viable test results; disturbance to the borehole-wall shall be minimized, and in case of having difficulties to form a satisfactory pocket, the probe shall be driven into the precored hole with thin wall slotted steel casing.

One (1) borehole for every 7,000m2 shall be cored (in Manmade Fill, and according to ASTM D6640) to a depth of 4m / to a depth of reaching the Gravely very Silty fine SAND (seabed sediments) before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling). The core descriptions shall be according to BS 5930 - Section 8.

Perforated (one third of the standpipe) uPVC pressure pipes (according to ASTM D1785), 73mm in OD and 5.2mm thick, wrapped with geotextile (PP, 150 gr/m2) shall be installed into the boreholes as open standpipe-piezometer (and a casing for the Static Cone Penetration Test that will be executed in the same location) with concrete heading (the number of the borehole, its depth and elevation shall permanently be written on concrete head) and steel pipe protection, to measure the depth and fluctuations of the groundwater table after air lifting.

Static Cone Penetration Test with Pore Pressure Measurement (CPTu / Piezocone Sounding) in Seabed Sediments:

A cone with electrical sensors shall be driven into Gravely very Silty fine SAND (seabed sediments) at a standard rate of penetration 2cm per second.

One (1) CPTu sounding for every 7,000m^2 shall be performed (according to ASTM D5778) to a depth of 15.5m (14m + 1.5m) / to a depth of cone refusal (50MPa) / to a depth of reaching the bedrock (Calcareous SANDSTONE / very Sandy LIMESTONE) from the seabed-level, before and 30 days

after Deep Dynamic Compaction (including final leveling and smooth rolling). The cone shall be equipped with friction reducer (if needed / where needed), to improve the depth of penetration.

A truck (reaction frame of 25 tons) mounted trust mechanism of GEOMIL (or equivalent having pushing and pulling forces of >= 200kN and >=150kN, respectively) with cone data acquisition system shall be used in CPTu.

The truck mounted trust mechanism shall be setup by using hydraulic pistons, to obtain a trust direction as near as possible to the vertical. The non-verticality of the sounding shall continuously be measured with slope sensors, to avoid breaking the push rods.

The continuously measured analogue data (cone resistance, sleeve friction, friction ratio and dynamic pore pressure) shall be converted to the digital form at 25mm intervals. Zero load readings of all sensors (reference measurements) shall be recorded at the start and end of each CPTu sounding. Calibrations shall be carried out at regular intervals based on the stability of the zero load readings with functional checks during the work.

Semi-empirical correlations will be used to estimate the following geo-mechanical parameters (CPTu interpretations).

- Soil profile (normalized/non-normalized soil behavior type),
- Equivalent SPT N60 profile,
- Soil unit weight,
- Undrained shear strength,
- Soil sensitivity,
- Undrained shear strength ratio,
- Over consolidation ratio,
- In-situ stress ratio,
- Friction angle,
- Relative density,
- Stiffness and modulus,
- Hydraulic conductivity,
- Consolidation characteristics (coefficient of consolidation), and
- Constrained modulus (estimating the consolidation settlement).

All above-mentioned works shall be executed as directed by the Engineer, and the Engineer shall be provided by the Contractor with verification test reports for his approval.

2.10 Safety Program

A detailed safety program will be required to provide protection for job site personnel / off-site personnel and adjacent properties. This safety program should be submitted prior to commencement of the work for review and approval by the Engineer.

The safety program should include required setback distances from the point of impact from the weight for personnel so that they are not within range of flying particles that may occur from impact of the weight into the ground. It should also include the manner in which the cable is attached to the tamper and the frequency of safety checks on the cable and associated equipment to prevent failure during DDC operations.

Photographs should also be made of nearby structures / adjacent properties that might be affected by the DDC operations and included with the safety plan submittal. All items associated with the safety program shall not be paid for separately, but shall be included in the cost of the DDC operations.

2.11 Records

The Contractor shall keep accurate records of the DDC operations, i.e., the locations where the drops have been made, the number of drops per grid-pattern location, depth of crater penetration, amount of Engineering Fill - 0/304.8mm used in backfilling the craters, the pass number, ground surface elevations following each pass, and these results shall be available in the Contractor's site office on a daily basis. On a weekly basis, this information shall be submitted to the Engineer for his approval.

Any circumstances affecting the work or intended improvement as a result of DDC should be brought to the attention of the Engineer.

2.12 Final Report

A final report giving full description of site, site preparation, DDC equipment, DDC works (including monitoring), additional works (if any) and results of verification tests (including depth and degree of improvement) shall be prepared and submitted to the Engineer for his approval as One (1) soft and Three (3) hard copies.

The report shall include (but not limited to):

- Current topography,
- As-built drawings (Plans and Sections),
- Weekly records,
- Site photos,
- Engineering analysis as requested by the Engineer, and
- Conclusions / recommendations.

3 PARTICULAR SPECIFICATIONS FOR DEEP DYNAMIC COMPACTION WORKS – AREA PHASE 2B (47,988M^2)

3.1 Introduction

The Area Phase 2b is represented by the Boreholes BH4

BH4 at elevation +1.25

0-3.5m:

Medium dense (according to SPT values) partially saturated/submerged Manmade Fill (Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders),

3.5-18m:

Gravely very Silty medium dense to dense (according to corrected SPT and/or DCPT values for the increase resistance due to negative excess pore water pressure set up during the testing) fully saturated/submerged poorly graded fine SAND of intermediate plasticity.

Neither medium dense Manmade Fill nor the multi-layered foundation soil (Manmade Fill and underlying Gravely very Silty medium dense to dense fine SAND) with water table (seawater) at bottom level of foundation, cannot be considered safe bearing strata for the Expansion and Upgrade of Al-Ghadir WWTP, accordingly; the multi-layered foundation soil shall be densified by Deep Dynamic Compaction from the elevation +2.00, and the type of foundation shall be enlarged-raft,

taking the heterogeneous Manmade Fill (Type-S1 that is rarely used, Type-S2 that is mostly used and Type-S3 that is moderately used) into consideration.

3.2 Description of Work

The work shall consist of densifying the Manmade Fill (medium dense partially saturated/submerged Silty Sandy GRAVEL of intermediate plasticity with Cobbles and Boulders, 4.25m (3.5m + 0.75m thick additional fill, to reach elevation +2) thick in average and Favorable for Deep Dynamic Compaction (Zone 1) according to FHWA-SA-95-037, 1995) and underlying very Silty fine SAND of intermediate plasticity (medium dense to dense fully saturated / submerged, >14.5m thick in average and Intermediate for Deep Dynamic Compaction (Zone 2) according to FHWA-SA-95-037, 1995) by Deep Dynamic Compaction (DDC) to the area and extent shown on the drawings (47,988m^2) and to a depth of 18.75m from the elevation +2, prior to Expansion and Upgrade of Al-Ghadir WWTP.

The work shall be performed by a Specialty Contractor who can meet the requirements. The Specialty Contractor shall furnish all equipment (including but not limited to crawler cranes, pounders, impact rollers and seismograph) that are in good and safe working condition, labor and materials necessary or incidental to the completion of the DDC for this project.

3.3 Description of Deep Dynamic Compaction

The DDC is a process whereby a heavy tamper is repeatedly raised and dropped from a specified height to impact onto the ground surface, thereby transmitting high compaction energy into the soil mass. The tamper shall be raised and dropped by a single cable with a free spool hoisting drum (80% efficiency). The depth of improvement depends upon the tonnage of the weight, the height of the fall and the amount of energy applied per unit area.

The tamper weight shall be constructed to resist the high impact stresses. The high energy compaction (Phase 1) shall be applied in Three (3) passes which is designated on the drawings as the 1st pass (5 nos. of drops at each grid-point), 2nd pass (5 nos. of drops at each grid-point) and 3rd pass (4 nos. of drops at each grid-point) locations. After energy application at any 1st pass location, there shall be a minimum waiting period of three days before energy application at 2nd pass location, to allow the excess pore water pressure to dissipate between the passes. The high energy compaction consists of dropping the tamper (32ton) from a height of 33.5m to impact the surface on a grid pattern of 6m by 6m. The pass is described as either of the following, whichever occurs first:

- The application of all the specified drops at a grid-point location, or
- Whenever the crater depth reaches 1.5 to 2m regardless of the number of drops at a grid-point location.

After each drop, craters created by the tampers (shallower than 1.5 to 2m) shall be backfilled and graded with quarry runs Engineering Fill - 0/304.8mm (A-1-a with fines up to 15%) before the next drop is applied.

The Engineering Fill - 0/304.8mm shall be well graded (coefficient of curvature between 1 and 3), and shall have a minimum 4-days soaked CBR of 45% at 95% proctor density.

The Engineering Fill - 0/304.8mm shall be tested as follows, and shall be approved by the Engineer prior to start backfilling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),

- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 95% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The Engineering Fill - 0/304.8mm shall also be tested as mentioned-above during the execution for every 7,000m^2 compacted with high energy (or at least once for a section less than 7,000m^2), and the lab test results shall be submitted to the Engineer for his approval.

After the 3rd pass of high energy compaction (Phase 1) has been completed, the ground surface shall be levelled and a low energy compaction called ironing phase shall be applied in Two (2) passes which is designated on the drawings as the 1st pass (2 nos. of drops at each grid-point) and 2nd pass (2 nos. of drops at each grid-point). The ironing pass consists of dropping the tamper (15ton) from a height of 5m to impact the surface with continuous overlapping.

The impact rolling then final leveling (leveling course) and after that smooth rolling shall follow the ironing phase. The impact rolling (at least 12 nos. of passes) shall be done by using impact rollers (12-ton class and 25 Kilojoules of potential energy, each) with 3-sided non-circular steel drum running at a speed of 9kph, and the smooth rolling (at least 6 nos. of passes and/or until reaching >=96% of proctor density) shall be done by using 15-ton class single-drum vibratory smooth rollers. At least 2 nos. of impact and 2 nos. of smooth rollers shall be provided by the Contractor.

The quarry runs Leveling Course - 0/101.6mm (A-1-a with fines up to 10%) shall be well graded (coefficient of curvature between 1 and 3), and shall have a minimum 4-days soaked CBR of 60% at 96% proctor density. The Leveling Course shall be placed in compacted (>= 96% of proctor density) layers of 20cm thick each with respect to its maximum and nominal maximum aggregate sizes of 10 1.6mm and 76.2mm (respectively).

The Leveling Course - 0/101.6mm shall be tested as follows, and shall be approved by the Engineer prior to start leveling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 96% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The Leveling Course - 0/101.6mm shall also be tested as mentioned-above during the execution for every 7,000m^2 leveled and compacted by using smooth roller (or at least once for a section less than 7,000m^2), and the lab test results (including Field Density for every 2000m^2) shall be submitted to the Engineer for his approval.

3.4 Deep Dynamic Compaction Equipment

The Contractor shall provide the equipment capable of raising (up to 33.5m) and dropping tampers (up to 32 tons) on a repeated basis without a significant amount of down time. The Contractor shall also provide equipment to backfill and grade the craters created by the tampers after each drop.

The Contractor shall provide a minimum of One (1) crawler crane (>=150 tons with cable size of >= 38mm) and One (1) set of tampers (32 tons octagonal and 15 tons square, both with base area of 4m^2) for the high and low energy compaction. The contact pressure which is the weight of tamper divided by the base area shall be in the range of 37.5 to 80kPa.

The Contractor shall stake (with wood lathe or wire markers with flags) all of the grid-point locations as shown on drawings. The tamper shall be dropped with the staking accurate to the nearest +/- 0.3m. Following each pass, the stakes or wire markers with flags shall be replaced for the next pass.

3.5 Site Preparation

The high- and low-level areas shall be cut and filled (respectively) to elevation +2.00, and filling the low-level areas shall be done by using the granular material resulted from cut and imported A-2-5 to A-2-6 material with Cobbles (more or less 18%) and Boulders (more or less 8%). The imported A-2-5 to A-2-6 material (0/304.8mm) shall have a minimum 4-days soaked CBR of 20% at 95% proctor density.

The imported A-2-5 to A-2-6 material (0/304.8mm) shall be placed in semi-compacted (more or less 92% of proctor density) layers of 45cm thick each with respect to its maximum and nominal maximum aggregate sizes of 304.8mm and 203.2mm (respectively). The granular material resulted from cut shall also be semi-compacted.

The imported A-2-5 to A-2-6 material shall be tested as follows, and shall be approved by the Engineer prior to start filling.

- Organic impurities,
- Clay Lumps and Friable Particles,
- Flakiness and Elongation Index,
- Liquid Limit (LL),
- Plasticity Index (PI),
- Sand Equivalent (ES %),
- Specific Gravity (Saturated Surface Dry) and Water Absorption,
- Proctor Density & Optimum Water Content,
- 4 days Soaked CBR at 96% proctor density,
- LA (500 revolutions),
- Soundness, and
- Compressive Strength and/or PLI

The imported A-2-5 to A-2-6 material shall also be tested as mentioned-above during the execution for every 7,000m2 filled and semi-compacted by using smooth roller without vibration (or at least

once for a section less than 7,000m^2), and the lab test results (including Field Density for every 2000m2) shall be submitted to the Engineer for his approval.

As for the cut, the sharp vertical drops shall be flattened to provide access for the crawler crane for lifting and dropping of the tampers. The small hills or stockpiles of miscellaneous material should be smoothed out and bladed to a more nearly level surface at elevation +2.00

A seismograph shall be used to measure the magnitude of ground vibrations being transmitted off-site. The Particle Velocity (at frequency of 6 to 10 hertz) shall be less than 19mm/sec during the DDC, accordingly; the overall DDC area shall be surrounded by a 3m deep and 0.6m wide trench as a ground-vibration barrier within a setback of 6m, to minimize the effect of ground-vibration and lateral soil-mass displacement on neighboring structures (such as the side-slopes of landfill cells and airport's runway).

An open trench is the most effective in reducing vibrations, however; open trench is concern for side-slope stability of landfill cells and airport's runway. Accordingly, the open trench shall be backfilled with loosely placed (dumped) compressible material resulted from excavation of the trench.

3.6 Deep Dynamic Compaction Sequence

The total area for high energy compaction (Phase 1) can be divided into smaller work sections (such as 72m by 72m) with one section completed before another section is started, however; the low energy compaction (ironing phase) and impact rolling as well as final leveling and smooth rolling shall be applied to overall DDC area (47,988m2).

Based on previous experience Lukas (FHWA-SA-95-037, 1995) recommends a maximum depth of improvement (d max) that can be achieved, given by:

d max = n (WH)^0.5

Where W is the tamper weight in tones, and H is the height of drop in m. The value of n depends on soil type, and decreases with an increase in degree of saturation.

Phase 1: High Energy Compaction with 3 nos. of passes on a grid pattern of 6m by 6m (see below Figure 3).

- 1st Pass (5 nos. of drops at each grid-point location), for W=32ton and H=33.5m;

  Energy per drop=32ton*9.807*33.5m=10.5MJ, and

  d max=0.4(32*33.5) ^0.5=13m < 18.75m, the DDC will be limited to 13m,

- 2nd Pass (5 nos. of drops at each grid-point location), for W=32ton and H=33.5m;

  Energy per drop=32ton*9.807*33.5m=10.5MJ, and

  d max=0.4(32*33.5) ^0.5=13m < 18.75m, the DDC will be limited to 13m,

- 3rd Pass (4 nos. of drops at each grid-point location), for W=32ton and H=33.5m;

  Energy per drop=32ton*9.807*33.5m=10.5MJ, and

  d max=0.4(32*33.5) ^0.5=13m < 18.75m, the DDC will be limited to 13m,

Unit Applied Energy (kJ/m3) =(N*W*H*P)/Grid Spacing^2, where N: Average Number of drop and P: Number of Passes,

Unit Applied Energy=(4.7*32ton*33.5m*3)/6^2=420kJ/m3*0.8 (80% efficiency) =336kJ/m^3,

250kJ/m^3<336kJ/m^3<350kJ/m^3 for semipervious fully saturated / submerged very Silty fine SAND (Zone 2), CONFIRMED with a Total Applied Energy of 4,368kJ/m^2 (336kJ/m^3*13m).

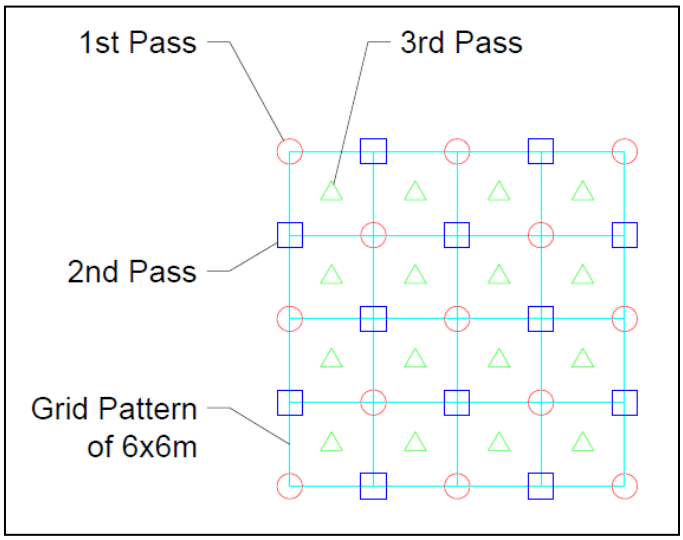


Figure 3

Low Energy Compaction: Ironing phase with 2 nos. of passes.

- 1st ironing pass with continuous overlapping (2 nos. of drops), for W=15tons and H=5m;

  Energy per drop=15ton*9.807*5m=0.7MJ, and

  d max=0.5(15*5) ^0.5=4.3m > 4.25,

- 2nd ironing pass with continuous overlapping (2 nos. of drops), for W=15tons and H=5m;

  Energy per drop=15ton*9.807*5m=0.7MJ, and

  d max=0.5(15*5) ^0.5=4.3m > 4.25,

Unit Applied Energy (kJ/m3) =(N*W*H*P)/Grid Spacing^2, where N: Average Number of drop and P: Number of Passes,

Unit Applied Energy=(2*15ton*5m*2)/1^2=300kJ/m3*0.8 (80% efficiency) =240kJ/m3,

200kJ/m3<240kJ/m^3<250kJ/m3 for Pervious partially saturated / submerged Manmade Fill (Zone 1), CONFIRMED with a Total Applied Energy of 1020kJ/m2 (240kJ/m3*4.25m)

Impact Rolling:

- The impact rolling (at least 12 nos. of passes) shall be done by using impact rollers (12-ton class and 25 Kilojoules of potential energy, each) with 3-sided non-circular steel drum running at a speed of 9kph.

Final Leveling and Smooth Rolling:

- The smooth rolling (at least 6 nos. of passes and/or until reaching >=96% of proctor density) shall be done by using 15-ton class single-drum vibratory smooth rollers.15-ton class single-drum vibratory smooth-roller, at least 6 nos. of passes (>=98% of Proctor Density).

3.7 Additional Works

If the desired improvement (having dense to very dense Manmade Fill and underlying gravely very silty fine SAND that is called multi-layered foundation soil) has not been achieved upon completion of Deep Dynamic Compaction; additional energy could be applied, to result in greater ground improvement. This additional work will be paid at unit rate for Deep Dynamic Compaction (Phase 1 including backfilling and grading the craters, ironing phase and impact rolling).

3.8 Monitoring

The Deep Dynamic Compaction (DDC) operations shall be monitored. The monitoring shall include, but not be limited to observations of crater depths, monitoring ground-vibrations by using seismograph, determining the heave adjacent to craters that is a sign of excess porewater pressure and measuring the surface settlement on grid basis before and after DDC (before final leveling and smooth rolling) as requested by the Engineer.

The Contractor shall also be responsible for counting the number of drops at each grid-point location to be sure that the proper energy is applied. If any additional drops are requested by the Engineer, these shall also be recorded by the Contractor.

3.9 Verification Tests

The verification tests (Pressiometer and Static Cone Penetration) shall be executed before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling), taking the multi-layered foundation soil improvement with additional time (due to dissipation of the excess porewater pressure) into consideration, to determine the depth and degree of improvement.

Pressiometer Test (PMT) in Manmade Fill:

The precored (T2 76) Pressiometer test in Manmade Fill shall be performed (according to ASTM D4719) at 2m intervals by using Menard type volume displacement tricell probe 74mm in outside diameter with maximum working pressure of 10Mpa.

The Pressiometer test shall be performed, to obtain Menard Limit Pressure and Pressiometer Modulus. To obtain viable test results; disturbance to the borehole-wall shall be minimized, and in case of having difficulties to form a satisfactory pocket, the probe shall be driven into the precored hole with thin wall slotted steel casing.

One (1) borehole for every 7,000m2 shall be cored (in Manmade Fill, and according to ASTM D6640) to a depth of 4m / to a depth of reaching the Gravely very Silty fine SAND (seabed sediments) before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling). The core descriptions shall be according to BS 5930 - Section 8.

Perforated (one third of the standpipe) uPVC pressure pipes (according to ASTM D1785), 73mm in OD and 5.2mm thick, wrapped with geotextile (PP, 150 gr/m2) shall be installed into the boreholes as open standpipe-piezometer (and a casing for the Static Cone Penetration Test that will be executed in the same location) with concrete heading (the number of the borehole, its depth and elevation shall permanently be written on concrete head) and steel pipe protection, to measure the depth and fluctuations of the groundwater table after air lifting.

Static Cone Penetration Test with Pore Pressure Measurement (CPTu / Piezocone Sounding) in Seabed Sediments:

A cone with electrical sensors shall be driven into Gravely very Silty fine SAND (seabed sediments) at a standard rate of penetration 2cm per second.

One (1) CPTu sounding for every 7,000m2 shall be performed (according to ASTM D5778) to a depth of 15.5m (14m + 1.5m) / to a depth of cone refusal (50MPa) / to a depth of reaching the bedrock (Calcareous SANDSTONE / very Sandy LIMESTONE) from the seabed-level, before and 30 days after Deep Dynamic Compaction (including final leveling and smooth rolling). The cone shall be equipped with friction reducer (if needed / where needed), to improve the depth of penetration.

A truck (reaction frame of 25 tons) mounted trust mechanism of GEOMIL (or equivalent having pushing and pulling forces of >= 200kN and >=150kN, respectively) with cone data acquisition system shall be used in CPTu.

The truck mounted trust mechanism shall be setup by using hydraulic pistons, to obtain a trust direction as near as possible to the vertical. The non-verticality of the sounding shall continuously be measured with slope sensors, to avoid breaking the push rods.

The continuously measured analogue data (cone resistance, sleeve friction, friction ratio and dynamic pore pressure) shall be converted to the digital form at 25mm intervals. Zero load readings of all sensors (reference measurements) shall be recorded at the start and end of each CPTu sounding. Calibrations shall be carried out at regular intervals based on the stability of the zero load readings with functional checks during the work.

Semi-empirical correlations will be used to estimate the following geo-mechanical parameters (CPTu interpretations).

- Soil profile (normalized/non-normalized soil behavior type),
- Equivalent SPT N60 profile,
- Soil unit weight,
- Undrained shear strength,
- Soil sensitivity,
- Undrained shear strength ratio,
- Over consolidation ratio,
- In-situ stress ratio,
- Friction angle,
- Relative density,
- Stiffness and modulus,
- Hydraulic conductivity,
- Consolidation characteristics (coefficient of consolidation), and
- Constrained modulus (estimating the consolidation settlement).

All above-mentioned works shall be executed as directed by the Engineer, and the Engineer shall be provided by the Contractor with verification test reports for his approval.

3.10 Safety Program

A detailed safety program will be required to provide protection for job site personnel / off-site personnel and adjacent properties. This safety program should be submitted prior to commencement of the work for review and approval by the Engineer.

The safety program should include required setback distances from the point of impact from the weight for personnel so that they are not within range of flying particles that may occur from impact of the weight into the ground. It should also include the manner in which the cable is attached to the tamper and the frequency of safety checks on the cable and associated equipment to prevent failure during DDC operations.

Photographs should also be made of nearby structures / adjacent properties that might be affected by the DDC operations and included with the safety plan submittal. All items associated with the safety program shall not be paid for separately, but shall be included in the cost of the DDC operations.

3.11 Records

The Contractor shall keep accurate records of the DDC operations, i.e., the locations where the drops have been made, the number of drops per grid-pattern location, depth of crater penetration, amount of

Engineering Fill - 0/304.8mm used in backfilling the craters, the pass number, ground surface elevations following each pass, and these results shall be available in the Contractor's site office on a daily basis. On a weekly basis, this information shall be submitted to the Engineer for his approval.

Any circumstances affecting the work or intended improvement as a result of DDC should be brought to the attention of the Engineer.

3.12 Final Report

A final report giving full description of site, site preparation, DDC equipment, DDC works (including monitoring), additional works (if any) and results of verification tests (including depth and degree of improvement) shall be prepared and submitted to the Engineer for his approval as One (1) soft and Three (3) hard copies.

The report shall include (but not limited to):

- Current topography,
- As-built drawings (Plans and Sections),
- Weekly records,
- Site photos,
- Engineering analysis as requested by the Engineer (the limited depth of improvement shall be taken into consideration in analysis, reference is made to Section 3.6), and
- Conclusions / recommendations.

SECTION 03100
FORMWORKS

1 GENERAL

1.1 Work Included

This section covers the supply, installation and execution of formwork for concrete structures.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 03200 Reinforcement

C. Section 03250 Concrete structure joints

D. Sections 03300 Concrete

1.3 Description

Formwork shall be designed supplied and installed in order to produce concrete parts meeting specified shape, dimensional and position requirements, without defects or irregularities and within the prescribed tolerance limits.

1.4 Definitions

A. Abrupt irregularities

Any local irregularity resulting from incorrect alignment or relative displacement of the formwork, unsatisfactory condition of formwork or any other cause.

Abrupt irregularities will be measured directly or using a rule or a template of 20 cm long.

B. Gradual irregularities

Refer to any other difference between the theoretical and actual lines of the concrete faces. They shall be measured with a straight rule for plane surfaces and with an appropriate template for curved surfaces of 1.50 m long.

C. Honey combs, grout losses and surface plucking shall not be considered as irregularities but as defects.

1.5 Standards And Regulations

The following Standards shall be used, in this order of priority:

1. British Standards
2. European Standards.

1.6 Standards Of Finish

A. Class 1

This is a very high-quality finish where formwork shall ensure a particularly accurate line of finish: surfaces in contact with hydraulic flow and surfaces exposed to view:

1. The surfaces delineated by panel joints shall be regular.

2. Unless otherwise indicated, panel joints shall be vertical or horizontal, perpendicular or in alignment with the water flow.
3. Construction joints shall match architectural design details where necessary and shall be submitted for the Engineer's approval.
4. Formwork linking systems shall not be permitted unless otherwise approved by the Engineer.
5. All abrupt irregularities shall be ground to obtain chamfers of 1-over-50.

   For surfaces that will be subjected to flowing water at a rate of more than 10 m/s, no smoothing will be tolerated and any irregularity outside specified limits which cannot be repaired by bush hammering or grinding shall be repaired with epoxy resins or any other product approved by the Engineer. Such resins or products shall be applied by approved specialists.
6. All corners/changes in direction shall be fitted with appropriate chamfers, as approved by the Engineer.

B. Class 2

Formwork for structure surfaces and joints and, in general, all structures not requiring a special finish, i.e. surfaces not exposed to the view:

1. The surfaces delineated by joints between formwork panels shall be regular.
2. Unless otherwise indicated, joints shall be vertical or horizontal or parallel to the overall lines of the structure.
3. Construction joints positions shall be submitted for the Engineer's approval.
4. If accepted, formwork linking systems shall be placed uniformly with aligned joints as to achieve a symmetrical pattern in the finish concrete surface.

C. Class 3

1. Surfaces designed for construction joints between different construction stages with, where applicable, steel bars passing through them.
2. Surfaces designed to be coated at a later stage.

D. Class 4

Surfaces contained by formwork but which will be permanently concealed in the completed work.

E. Surface state tolerances in millimeters

Formwork class	Abrupt irregularities	Gradual irregularities
Class 1	2	6
Class 2	4	8
Class 3	8	15
Class 4	nil	40

N.B.: The clauses of this article are also applicable to concrete surfaces not effectively shuttered.

1.7 Design

A. Formwork and falsework shall support without appreciable deformation the weight of the fresh concrete, reinforcement and embedded parts as well as the forces induced by falling concrete, with vibration, impacts of handling equipment, personnel, temperature variations and climatic agents.

B. Joints between panels shall be grout tight and shall provide satisfactory continuity of concrete surfaces.

1.8 Curved Formwork

A. Curved surfaces of radius less than or equal to 2 m shall conform strictly to the theoretical curve.

B. Curved surfaces shall be given by curved formworks, even for 2D curved ones:

a) Either by plywood built on site,

b) Either by industrial curvable iron formworks.

1.9 Submittals

A. Working drawings of formwork with props, stays, spacers and fastening systems shall be submitted to the Engineer for information.

B. The specifications and manufacturer's instructions for the following items and products shall be submitted for the Engineer's approval:

1. Sheathings or liners.
2. Spacers and falsework.
3. Special supports embedded in the concrete if agreed on principle.
4. Dressing material for stripping.
5. Slip forms where applicable.

1.10 Layout Tolerances

A. Layout deviations of concrete facings shall be compatible with the functions of the structure considered and with related structural functions, especially with regard to mechanical supplies.

For electromechanical works, tolerances shall be indicated on the drawings.

B. Unless otherwise indicated, the positive and negative tolerances are as follows:

1. On any linear dimension L (in m), measured between opposing facings, edges or intersecting edges:

$$T\ (cm) = \frac{1}{4}\sqrt[3]{L}$$

with a minimum of 0.5 cm and a maximum of:

a) 1 cm for class 1 formwork

b) 3 cm for other classes of formwork

2. On vertical dimensions :

$$T(cm) = 0.0005 \times H$$

where:

H = height of the item in cm

Upper limits: 0.05 x E or 3 cm

E = thickness of the item in cm

3. On alignments or gradients:

$$T(cm) = 0.0005 \times L$$

where:

L = length in cm

For the curved parts, the tolerances are fixed by analogy

4. On the layout with respect to the reference marks indicated to the Contractor: planimetry and altimetry:

$$T\ (cm) = \frac{1}{2}\sqrt[3]{D}$$

where:

D = distance in meter between the control point and the reference mark with an upper tolerance limit of 3 cm and a lower limit of 0.5 cm.

2 PRODUCTS

2.1 Formwork Materials

A. Generally speaking, forms shall be made of wood or metal. Unless specified to the contrary, they shall be made of plywood for wood or exposed surfaces where the visual impact is particularly important and where no plaster will be applied (As for the tanks).

All panels other than metal panels shall be new when they are first used on site.

B. Panels may be reused on site on condition that they are carefully cleaned, reconditioned or surfaced from time to time and if they will be capable of producing concrete surfaces conforming to the specifications. After repeated use, the Engineer may require the Contractor to scrub the form or to provide new ones.

For finishes Class 1 the new plywood shall not be reused for more than once unless approved by the Engineer, based on maintaining a very good wood quality.

C. Spacers and fasteners shall be designed in such a manner that, after stripping, no metal part will be closer to the surface of the facing than the minimum concrete cover agreed for the reinforcement.

D. For water retaining concrete structure, a plate of 50 mm minimum diameter shall be welded in the middle of spacers and fasteners to avoid leakages. Tie rods with fixed water stopper shall be used for all immerged faces, where all the openings, following the removal of the moveable rods parts shall be appropriately filled with non-shrink material approved by the Engineer.

2.2 Dressing Materials for Stripping

A. Surfaces exposed to concrete must be coated with form oil or other approved dressing material.

B. Dressing material shall facilitate wetting of the form surface, reduce bubble formation, leave no notable trace on concrete surfaces and protect the form surface from any damage such as corrosion.

C. They shall be compatible with the treatment that may be applied to the concrete surfaces (painting, coating, etc.).

2.3 Excavated Surfaces Used as Forms

A. At the Contractor's request, and after the Engineer has given his approval, the lateral forms of buried parts of concrete structures may be omitted with the concrete being placed directly the excavated surfaces, especially where skin friction is needed. In such a case, the dimensions of the excavation shall be smaller than the excavations done for concreting with formworks.

B. In cases where the omission of formwork is accepted, the dimensions of the concrete parts shall be increased on each face in contact with the excavated surfaces.

C. At the Engineer's instruction, a layer of blinding concrete shall be spread or projected over the excavated surface (upon completion of subgrade soil preparation) before placing the concrete.

3 EXECUTION

3.1 Inspection

Reference levels and alignments, levels and positions of previous concrete lifts and the position of previously placed reinforcement bars shall be checked before installing the formwork.

3.2 Preparation

A. After cleaning, the forms shall be coated with a dressing material in accordance with the manufacturer's instructions.

B. The forms shall be protected from dust and dirt, after the above treatment.

3.3 Installation

A. The forms shall be installed and securely braced in such a manner that the concrete surfaces produced come within the tolerance limits defined in Part I herein.

B. If necessary, forms shall be installed with a counter deflection.

C. Unless otherwise indicated, exposed corners shall be provided with 25 x 25 mm chamfers by mean of moulding strip placed in the formwork.

D. Construction joints levels shall be provided with battens defining the limits between two concrete lifts, where directed by the Engineer.

E. Formwork for successive vertical lifts must make good contact with the concrete in the preceding lift, such that there will be no excrescences, bulges, tears or other outward signs of a faulty junction such as grout leakage.

F. Blockouts, inserts and embedded items should be properly identified, positioned and secured.

3.4 Stripping Of Forms

A. Formwork shall not be removed without the approval of the Engineer. Notwithstanding this approval, the forms shall not be moved or removed until the concrete has acquired sufficient strength to support its weight and the construction or design loads that it may be required to bear.

B. Stripping shall take place without impact or vibration to the concrete and care shall be taken not to damage the concrete surfaces.

C. Stripping operations may be decided in relation to the results of compression tests on specimens kept under conditions similar to those of the structure considered. These test specimens shall be taken in addition to the test pieces specified in section on concrete.

D. Concrete compressive strength tests may be replaced by sclerometer measurements, following the Engineer’s directions.

E. Generally speaking, the forms and supports of suspended structures shall not be removed until the ratio of the compressive strength of test specimens kept under similar conditions to those of the structure considered to the specified strength is greater than the ratio of the deadweight plus construction loads to the design load, with a minimum value of 0.50.

F. In general, formwork shall be left in place for the following period after the concrete is cast:

1. minimum of 36 hours: vertical surfaces of piers and columns,
2. minimum of 36 hours: vertical surfaces of footings, walls and dams,
3. minimum of 20 days: suspended beams and slabs,
4. minimum of 12 hours: tunnel linings,
5. minimum of 7 days: arch roof of underground chambers.

The times above specified shall have elapsed from the end of concreting. According to the results of the laboratory tests and site trials, the aforesaid minimum times may be reconsidered by the Engineer. In all cases, the Contractor shall demonstrate that removal of formwork will not in any way adversely affect the concrete of permanent work.

3.5 Repair of Surface Defects

A. If the concrete surfaces after stripping have certain local defects (such as honey combs or surface defects) or irregularities, the Contractor shall advise the Engineer before undertaking any repairs so that the said defects and irregularities can be inspected and notified in a jointly signed report.

B. If in the Engineer's opinion that the defects will not have any significant impact on the quality of the structure, the Contractor shall propose the necessary repair work prior to any repairs.

C. In case of serious defects, the Engineer may order the whole lift concerned to be removed and replaced.

D. Repairs of local defects and holes left by form fasteners and spacers shall be carried out using cement mortar containing an adhesive and an additive mixture to prevent shrinkage.

E. Holes left by form fasteners and spacers may, for certain concrete facings not in contact with water, be left as they are, with the Engineer's approval.

F. Spalling, burrs and irregularities not compatible with specified type of finish shall be repaired by smoothing as specified for defects, or ground.

G. Within 24 Hours after form removal all fins and loose materials shall be removed and surface defects including the holes shall be remedied unless otherwise required by the Engineer.

SECTION 03200
REINFORCEMENT

1 GENERAL

1.1 Work Included

This section covers the supply and installation of steel bars or steel fabrics used for reinforcement in concrete works, either for permanent or for temporary structures.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 03100 Formworks.

C. Section 03250 Concrete structure joints.

D. Sections 03300 Concrete.

1.3 Quality Assurance

1.3.1 Codes and Standards

The following Standards shall be used, in this order of priority:

1. British Standards.
2. European Standards.
3. American Standards.

1.3.2 Tests And Inspection

A. The Contractor shall provide the Engineer with the Supplier's Certificate and/or mill certificates, and the Contractor shall bear the cost of testing (before and during the execution) to be carried out in an approved laboratory.

B. The tests will cover the following characteristics:

1. Diameter (determined by weighing)
2. Tensile strength
3. Bending/rebending tests

C. Six samples per diameter shall be taken for determining each of the above-mentioned characteristics.

D. If two tests of a given characteristic give unsatisfactory results, the reinforcement bars concerned shall be considered defective.

E. If one test of a given characteristic gives an unsatisfactory result, a new sampling of six samples from the same batch shall be taken for a new series of tests on the characteristic in question. If the results of the new tests are all satisfactory, the reinforcement bars will be accepted. If this is not the case, the bars shall be considered defective.

1.4 Submittals

A. Supply of steel bars

Manufacturer's test certificates of mill certificates including details of physical and chemical properties.

B. Welding of reinforcement bars will not be allowed

Nevertheless, in particular cases, the Engineer could agree with bars welding; in such cases the required design reinforcing area shall be maintained and the following documents will be submitted to the approval of the Engineer.

1. A welding programme.
2. Certificates of steel reinforcement weldability.

C. Spacers shall be submitted to the approval of the Engineer.

1.5 Tolerances

A. Tolerance on the distance (d) between reinforcement bars in walls, slabs or beams:

1. 0.5 cm for d less than 15 cm
2. 1.0 cm for d between 15 and 80 cm
3. 2.0 cm for d greater than 80 cm

B. Tolerance on length of bars: + 4 cm except when these bars are in a discontinuity zone (support surface, etc.) where the tolerance will be + 1.5 cm.

C. Tolerance on concrete covering thickness:

1. Minus 15% with a maximum of 10 mm
2. Plus 30%

2 PRODUCTS

2.1 Steel Grades

The following types of steel shall be used for reinforcement:

1. High yield steel bars conforming to BS 4449
2. Plain round mild steel, conforming to BS 4449, could be used as ties or stirrups or for temporary works, as directed by the Engineer.
3. Cold worked steel bars conforming to BS 4461.
4. Fabric reinforcements made of cold drawn high tensile bars conforming to BS 4483.

Reinforcement shall be High yield corrugated steel bars conforming to BS 4449 (or equivalent ASTM) as well as BS EN 1992-1 and BS EN 1992-3, with a minimum yield strength (noted fyk in BS EN 1992-1) of 460 MPa and a minimum characteristic strain (εuk) of 8%, which corresponds to a class C of ductility in BS EN 1992-1.

2.2 Reinforcement Spacers

A. Spacers may be made of metal, concrete, cement mortar or plastic.

B. Metal spacers or metal chairs shall not come into contact with the formwork.

C. Concrete or cement mortar spacers shall be of sufficient size to remain stable and shall be of equivalent quality to that of the concrete.

D. Unless their actual shape makes them perfectly stable, all spacers shall be provided with systems for attaching them to the reinforcement.

2.3 Delivery of Steel Reinforcement

A. When the steel bars for concrete reinforcement are delivered on site, they must be straight, without bends or windings, without stains/rust/corrosion or other damage. Bars accidentally bent will be rejected; however, after removal of the bent parts, the remaining straight sections could be accepted if the available length is sufficient.

B. When the steel reinforcement is delivered already shaped and assembled, it will be transported to the place of use with great care to ensure that no parts will not be permanently deformed/rusted/corroded.

2.4 Storage of Steel Reinforcement

A. The steel reinforcement bars shall be stored in such a manner that different diameters cannot be mixed.

B. Storage yards shall be clean and designed in such a manner that none of the steel reinforcement is in contact with the ground or subject to damp/wet conditions.

2.5 Welding of Bars

A. The Engineer may authorize end to end welding of steel bars and spot welds on bars as a replacement for binding, depending on the steel bar weldability certificates.

B. The Engineer will prescribe tensile and bending tests on welded parts in order to check the quality of welds and prove that the procedure will produce adequate strength and other necessary properties in the splice.

C. Where agreed, welding of bars shall be carried out in strict accordance with the steel Manufacturer's instructions.

2.6 Bending of Reinforcements

1. Steel reinforcement for reinforced concrete shall be fixed in accordance with the detailed Drawings to be prepared by the Contractor and approved by the Engineer. The Contractor shall provide bar bending schedules and shall be responsible for checking them and ensuring their accuracy before ordering and bending the reinforcement.

2. The bars shall be bent cold in a manner that will not injure the metal and in accordance with BS 4466. No bar exempt links and stirrups shall be bent to a smaller radius than twice its diameter. All bars which are lapped to secure continuity shall, unless otherwise stated to the contrary, overlap not less than the values given in BS 8110 (or as directed by the Engineer). Reinforcement projecting from partly finished work shall not be bent unless permitted by the Engineer and shall be protected from damage.

3 EXECUTION

3.1 Preparation

Film of rust on steel reinforcement will be permitted but rust which is loose or flaky shall be wiped off firmly with burlap or wire brushed.

3.2 Placing of Reinforcement

1. Before being fixed in position all reinforcing bars shall be cleaned of all mill scale, rust, dried grout, paint, oil, grease, earth or any other substance which may impair the bond between the reinforcement and the concrete.

2. The reinforcement shall be placed and securely fixed in the exact position required and the Engineer` s approval obtained before concreting is commended. On walls the horizontal and vertical bars shall be securely bound together with 16 s.w.g annealed soft iron wire at intervals not exceeding 400 mm and at all intersection.
3. The ends of links and bindings shall be bent around the bars for at least 225 degrees so as to fit tightly.
4. Fabric reinforcement when laid adjacent to other sections of reinforcement or when lapped shall have a minimum lap of 300 mm for the main wires and 150 mm for transverse wires (or as stated in BS 8110).
5. Anchorage length and overlap length shall not be inferior to 60 times bar diameter, unless stated otherwise in BS 8110 based on the Engineer's approval.
6. Reinforcement in angles shall be placed taking into account the unwanted thrust effect from curved rebars in tension.

3.3 Covering of Reinforcement Bars

Unless otherwise indicated, the minimum thickness of concrete covering the steel reinforcement shall be as follows:

1. For concrete cast directly against earth: 7,5 cm
2. Concrete in contact with water and atmospheric or aggressive agents: 5 cm (protection such as coating or painting shall be neglected, unless if approved by the Engineer)
3. Concrete in dry rooms: 3 cm
4. The covering over all reinforcement is to be at least equal to:
   c) its diameter (Φ) if it is a single bar,
   d) Φ x n 0,5 if it is a group of n bars, with a maximum of 55 mm
5. The concrete cover of the horizontal bars of a vertical layer of reinforcement shall exceed 4/3 of the maximum nominal aggregate diameter.

The aggressivity of liquids and exposure conditions according to BS5328 (such as XS3) shall also be taken into consideration by the Contractor

3.4 Minimum Reinforcement for Reservoirs

In addition to BS EN 1992-1 and BS EN 1992-3, the following criteria apply for reservoirs:

For reservoir walls, the steel section of reinforcement (in m²) shall not be inferior to 0,125 % of wall width (in m) on each face and both vertically and horizontally.

For reservoir raft, the steel section of reinforcement (in m²) shall not be inferior to 0,25 % of raft thickness (in m) in each direction. This section shall be spread on the top and bottom layer of reinforcement.

The reinforcement shall be validated by the contractor through structural calculation notes, and shall be approved by the Engineer.

3.5 Protection

As the concrete sets, after it has lost its plasticity, the steel reinforcement shall not be subjected to shocks or any external force (bending or use of bars for moving personnel) for a period of 48 hours.

SECTION 03250
CONCRETE STRUCTURE JOINTS AND NEOPRENE BEARING PAD

1 GENERAL

1.1 Works Included

This section covers the supply, installation or execution of different types of joints in all concrete structures and neoprene bearing pads.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 02232 Roads

C. Section 03300 Concrete

D. Section 03100 Formworks

E. Section 03200 Reinforcement

1.3 Definition and Description

A. Contraction joint

1. It is a contact between 2 elements generally without continuity of reinforcement, or half continuity of reinforcement.
2. Such joints will enable concrete cracks to be localized and construction phases to be localized.
3. They shall have no filler material (concrete cast against concrete).

B. Expansion joint

1. An expansion joint is formed by creating complete discontinuity with clear gap between 2 elements.
2. The purpose of expansion joints is to prevent structural disruptions as a result of temperature variations or differential movements, including earthquake effects in seismic regions.
3. The joints shall be filled with preformed joint filler.

C. Construction joint

1. The continuity of both concrete by special preparation and of reinforcement shall be assured.
2. These joints localize construction phases.

D. Sealing strip (or waterstop)

1. Watertight sealing is achieved by a natural rubber or PVC strip held in the two parts of structures in contact.
2. Strips shall be fitted to construction joints and to contraction and expansion joints, especially for water/wastewater structures and where directed by the Engineer.

E. Joint sealing compound

Joints may be sealed with an elastomer joint-sealing compound.

F. Neoprene bearing pads:

These elements shall provide vertical support and allow small horizontal displacements. They can be used for example between roof slabs and supporting water retaining walls under temperature shrinkage or during earthquake.

G. Preformed gap filler:

For the remaining part of gap in expansion joint and around neoprene bearing pad.

1.4 Quality Assurance

All the products used in joint work shall be of proven quality and shall be obtained from reputable manufacturers and approved by the Engineer.

1.5 Standards And Codes

The following Standards shall be used, in this order of priority:

1. ASTM D1751
2. British Standards.
3. European Standards.

1.6 Submittals

A. Technical data sheets giving the physical, chemical and mechanical characteristics of:

1. Sealing strips and special connection parts
2. Preformed joint fillers
3. Joint sealing compound
4. Neoprene bearing pads

B. A sample of all the products to be used in joint construction.

C. Results of quality control tests carried out in the factory on sealing strips and joint sealing compound.

D. Manufacturer's instructions for the storage and use of products.

1.7 Tolerances

A. Sealing strips

1. With respect to the formwork before pouring of concrete: 5 mm in all directions.
2. With respect to the final faces of the structure after pouring of concrete: 20 mm in all directions.

B. Joint sealing

After making the joint, the surface of the facing shall be continuous and smooth and shall not have any local irregularity greater than 5 mm.

C. Bridge joints

1. The level difference between the top carriage way surface of the bridge joint and the finished surface of the bridge deck shall be less than 5 mm.
2. The level difference between the 2 sectional irons forming the built-in part of the joint shall be less than 2 mm.

D. Neoprene bearings

1 mm in flatness and horizontality for lower surface (head of water retaining wall) and upper surface (roof slab).

2 PRODUCTS

2.1 Sealing Strips and Connection Parts

A. Material

Sealing strips shall be of rubber sections for type 1 and polyvinyl chloride (PVC) for type 2 waterstop.

Type 1 will be used for expansion joints or contraction joints in structures bearing a water pressure more than 5 mwc.

Type 2 will be used for contraction joints.

B. Rubber Material Characteristics

	At 25°C	**After aging (48h at 70°C under 2 MPa of Oxygen)**
Tensile strength greater than Elongation on rupture greater than Percentage of cinders less than Shore hardness	20 MPa 450% 4% 60 to 70	15 MPa 350% 4%

C. PVC material characteristics

	At 25°C	**After aging (48h at 70°C under 2 MPa of Oxygen)**
Tensile strength greater than Elongation on rupture greater than Maximum water absorption after 48 h immersion at 50°C Shore hardness	12 MPa 250 % 3 % 50 to 60	15 MPa 350 %

D. Range of dimensions (in mm)

Type	**Width**	**Centre bulb**	**Outer flanges**
1	300-350	45-55	23-27
2	200-230	No	18-22

E. Protection

During storage, sealing strips shall be protected from UV light.

2.2 Preformed Joint Filler

The preformed expansion joint fillers shall consist of a compressible, rot-proof and elastic material of the Flexcell or equivalent type conforming to ASTM D1751.

2.3 Joint Sealing Compound

A. The joint sealing compound will be an elastic, adhesive, waterproof elastomer capable of stopping the intrusion of foreign materials in the joint.

B. The product shall not have any chemical action on the materials with which it will come into contact (concrete, preformed joint filler).

C. Characteristics

1. Density: 1700 kg/m³ minimum

2. Shore hardness: 25-30
3. Consistency after polymerization: Rubbery
4. Proportion of solvent: Nil
5. Shrinkage: Nil
6. Vertical creep: Nil
7. Minimum deformation: 25 %
8. Minimum deformation in compression and traction without bond breaking, creep or cracking in the temperature range of 0-70□C.

2.4 Bridge Joints

A. Bridge joints shall be formed by steel and neoprene rubber.

B. Bridge joints shall be of the medium-heavy type capable of accommodating movements of 20-30 mm.

2.5 Neoprene Bearing Pads

Same quality as for bridge joints but without reinforcement of steel plates. Sticking with approved glue on its sub-surface.

3 EXECUTION

3.1 Inspection

All the products making up the joints (sealing strips, special parts, preformed joint filler, joint sealing compound, bridge joints) will be inspected and checked by the Engineer before installation.

3.2 Sealing Strips and Special Parts

A. Sealing strips as well as special intersection or connection parts, shall be fastened to the formwork or the reinforcement so as to keep them in the correct position as defined on the drawings during concreting operation.

B. Under no circumstances shall sealing strips fastening devices compromise watertightness (nailing for example).

C. Sealing strips as well as special intersection or connection parts shall be interconnected in order to guarantee total continuous sealing. The method of connection shall be of an approved type such as hot-vulcanized connection using an electric vulcanizer, or cold connection using a preformed rubber sleeve, and special solvent, as specified by the manufacturer of the strips.

D. The Contractor shall take particular care when concreting around the sealing strips. The consistency, particle size distribution, placing and internal vibration of the concrete shall be such that encasing is obtained. Large aggregates shall in all cases be removed from the strip encasing zone.

E. Restarting parts of sealing strips or special parts shall be protected from the risk of mechanical accidents and, if necessary, from the effects of solar radiation if the exposure time were to exceed one month.

F. All sealing strips or special parts incorrectly installed or connected, punctured or damaged, will be rejected and replaced with no extra cost to the Client.

3.3 Preformed Joint Filler

A. The preformed joint fillers shall be installed in the positions defined on the drawings against the first concreted face of the joint.

B. The method of fixing the preformed joint filler (copper or bronze nailing or bonding with an adhesive compatible with the filler material) shall ensure proper stability of the joint filler before and during concreting.

C. Joints between preformed joint filler panels shall be made watertight in order to prevent the penetration of underlying cement grout.

3.4 Joint Sealing

A. The edges of joints shall not show any signs of spalling or beading. Any repairs that may be required on the joint lips shall be carried out using epoxy resins approved by the Engineer.

B. Before filling with the joint sealing compound, the joint faces shall be cleaned of any loose laitance by sand-blasting or grinding or brushing. The faces shall be clean and dry when the mastic compound is applied.

C. The joint sealing compound shall be applied in strict accordance with the manufacturer's recommendations.

3.5 Bridge Joint

A. Anchor bars of bridge joint shall be welded to the reinforcement bars after testing the weldability.

B. The two parts of the bridge joint shall form an integral part during concreting of the second part of the joint and shall be separated as soon as concrete setting is done.

3.6 Neoprene Bearings

A. The reinforced neoprene pads shall be settled on perfectly flat and horizontal surfaces.

B. The performances (ashlar) of the bearing surfaces shall be slightly larger than the neoprene pad. The ashlars shall be refilled on pointed surface with a mortar dosed at 500 kg of cement per cubic meter of sand (or equivalent ready-dry-mix as directed by the Engineer). The neoprene bearings shall be placed on green mortar. For case in-situ structures the Contractor shall design a formwork system allowing for an easy stripping around the bearing.

SECTION 03300
CONCRETE

1 GENERAL

1.1 Work Included

This section covers the execution of concrete works for all structures.

1.2 Related Sections

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A.	Formwork	Section 03100
B.	Reinforcement	Section 03200
C.	Concrete structure joints	Section 03250

1.3 Standards And Regulations

A. Lebanese standards

All Lebanese standards shall be respected and have priority over the other standards listed below.

B. British Standard

BS EN 1992-1	Eurocode 2 - design of concrete structures - part 1-1: general rules and rules for buildings
BS EN 1992-3	Eurocode 2 - Design of concrete structures - Part 3: Liquid retaining and containment structures
BS EN 1998-1	Design of structures for earthquake resistance – General rules, seismic actions and rules for buildings
BS EN 1998-4	Design of structures for earthquake resistance – Silo, tanks and pipelines
BS EN 1998-5	Design of structures for earthquake resistance – Foundations, retaining walls and geotechnical aspects
BS EN 206-1	Concrete - part 1: specification, performance, production and conformity
BS EN 197-1	Cement - Part 1: composition, specifications and conformity criteria for common cements
BS l2	Specification for ordinary and rapid hardening Portland cement
BS l46: Part 2	Specification for Portland blast furnace cement (Metric units)
BS 340	Specification for precast concrete kerbs, channels, edgings and quadrants
BS 368	Precast concrete flags
BS 812	Grading of aggregates
BS 1200	Building sands from natural sources
BS 1881	Testing Concrete

BS 3148	Methods of tests for water for making concrete
BS 4027	Specification for sulfate-resisting Portland cement
BS 4246	Low heat Portland blast furnace cement
BS 5328	Methods for specify concrete
BS 5896	Specification for high tensile steel wire strand for the prestressing of concrete
BS 6073	Specification for precast concrete masonry units
BS EN 933-3	Tests for geometrical properties of aggregates
BSI 6089	Guide to assessment of concrete strength in existing structures

Equivalent ASTM and/or ACI Standards.

1.4 Submittals

A. The Contractor shall advise the Engineer not later than 2 months after the commencement date, by means of a detailed memorandum, of the arrangements he proposes to adopt regarding the production/source of sand and aggregates and the manufacture of concrete (batching plant), as well as for casting of the concrete.

B. Documents on concrete manufacturing

C. The Contractor shall submit to the Engineer's approval detailed drawings of the phases of concreting, specifying the locations of the various construction joints, any particular arrangements which may be required, and the order of implementation of the different phases.

D. Test results

The results of the tests shall generally indicate:

1. Identification number of sample.
2. Origin of sample.
3. Part of structures represented by the sample.
4. Drawing date of the sample.
5. Description of test with reference to a given standard.
6. Test result.
7. Date of test.

E. Cement

1. Test report for approval of cement before use.
2. Chemical and physical analyses for each make.
3. Copy of the cement storage record book submitted at the end of each week.

F. Aggregates

Test report for approval of aggregate before any use.

G. Water

Detailed memorandum for approval.

H. Additives

Test results.

I. Concrete

1. Concrete mix design.
2. Results of tests on mix design studies.
3. Results of concrete suitability tests.
4. Results of control tests.
5. Complete records shall be kept by the Contractor of all concreting. The records shall include the time of mixing and casting, weather conditions, quantity, mixture proportions, amount of additives, slump and water content of each cast, as well as the results of any tests made on the concrete.

1.5 Description

A. The major part of the concrete may be considered as medium to high reinforced concrete except in volume with some embedded items. In consideration of the behavior of massive concrete blocks (setting temperature, shrinkage) and for reasons of construction (concreting or/and equipment erection schedules, etc.) concrete shall be placed in a number of planned pours or lifts (a lift being defined as a volume of concrete poured without any interruption).

B. Except as otherwise specified or shown on the drawings or directed by the Engineer the extent of any horizontal length of a lift shall not exceed 15 m. The height shall in general not exceed 2.5 m, in some exceptional cases (with at least one small horizontal dimension) higher.

C. In the building parts such as service rooms, staircases, etc. reinforced concrete works with a medium to high percentage of reinforcement shall be involved. In principle, the above-mentioned provision concerning the massive concreting sections remains valid.

D. Finally, concreting sections will be provided such as second phase concrete for pockets or around embedded items. In these cases, relatively small quantities of concrete will be placed under confined conditions.

E. All concreting of contiguous lifts is separated by construction or expansion joints. In general, the reinforcement will be continued over the construction joints.

F. Pouring of lifts of limited dimensions does not exclude other means to avoid cracking such as the use of low heat of hydration cement, low cement ratio and refrigeration of concrete constituents.

G. All concrete shall be “hydraulic type concrete”, watertight by its own media.

2 PRODUCTS

2.1 Cement Quality

A. The cement shall be resistant to the aggressions from liquids and atmospheres. The cement shall be sulphate resistant and compliant with the NFP 15-319.

Elements exposed to XA3 and/or XS3 aggressions /exposure conditions shall be protected by coating.

1. The cement shall meet the following specifications:

Characteristics	Value	Test Method
Minimum compressive strength at 28 days	35 MPa	ASTM C 349
Initial setting time (Vicat needle) more than	90 mm	ASTM C 191
Initial setting time less than	180 mm	
Le Chatelier stability - cold and hot expansion less than	3 mm	NFP 15-432
Shrinkage at 28 days of mortar less than	0.08 %	ASTM C 596
+ chemical characteristics S03 less than	5 %	ASTM C 114
Hydration heat at 5 days (Langavant bottle) less than	260 J/g	NFP 15-436
+ equivalent sodium oxide (Na20+0.658 K20) less than	0.6 %	ASTM C 114
Potential alkali reactivity of cement - aggregate combination - expansion at:		
6 months less than	0.075 %	ASTM C 227
12 months less than	0.1 %	ASTM C 227

for cement only.

B. The mixing of cements or cement and mineral admixtures, such as milled slag, fly ash, pozzolan or fillers shall be authorized provided the effect of such blends made before mixing in the batching plant or during mixing be tested in accordance with the Engineer's instructions and the result submitted to the Engineer.

2.2 Approval of Cement Before Any Use

A. Each make of cement shall be constituted by cement from a homogeneous source (same factory, same fabrication process and same basic material).

B. The delivery of any make of cement to the primary silos at site shall not take place until written approval has been given by the Engineer, after examination of the test report. This test report shall be the result of tests carried out in the cement works or in a laboratory approved by the Engineer.

C. The tests shall include:

1. Flexural and compressive strength at 2,7, 28 and 90 days.
2. Initial and final setting time on pure paste.
3. Cold and hot expansion.
4. Shrinkage of cement mortar.
5. Chemical analysis.
6. Hydration heat (measured at 12 hours 1, 2, 3, 5 and 7 days) by the insulated.

   Langavant bottle method. (NF P 15-436) which is a semi-adiabatic measurement.
7. Potential alkali reactivity of cement aggregate combination (test duration: at least 2 years: the 6 months test will be extended for at least six additional months).
8. Blaine's specific surface (ASTM C 204).

D. Each characteristic shall be taken as equal to the average of three measurements made under each test (except for the compressive strength which shall be the average of 6 measurements).

2.3 Verification Of Cement Delivered

A. Control sampling shall be effected on each supply before the cement is delivered to the primary silos at site and when required by the Engineer.

B. Every 1000 t or not less than once a month, the following control tests shall be carried out:

1. Hot and cold expansion

2. Flexural and compression strength at 2 and 28 days
3. Initial and final setting time on pure paste
4. Blaine's specific surface

C. Every 5000 t or not less than once a month, the following control tests shall be carried out:

1. Heat of hydration (measured at 12 hours, 1, 2, 3, 5 and 7 days).
2. Chemical analysis.

D. Every 1000 t, and not less than once a month, a sample shall be taken at the silo of the batching plant and shall be kept in the laboratory for a minimum duration of 6 months (conservation samples). These samples (5 kg) are designed to allow the performance of tests a posteriori, in case of dispute or for information.

E. No cement shall be used before the flexural and compression strength at 2 days, the initial and final setting times, and the Blaine specific surface are known.

2.4 Cement Delivery

A. The cement shall be delivered in bulk or in bags, with the exception of cement for grouting, repair or finishing works or any other particular works, which will be delivered exclusively in bags.

B. Transport from the factory to the site shall be effected in watertight containers specially designed for this purpose.

C. The installations for transport from the container to the silo and from the silo to the mixer shall be watertight.

D. Once the supply in bags has been approved, the cement shall be delivered in bags of standard dimensions. The identification of the cement, the name of the manufacturer and the weight of the bags shall be clearly marked on each bag. Cement from damaged bags shall be neither used nor replaced in the bag without the prior approval of the Engineer.

2.5 Cement Storage

A. The cement supplied in bulk shall be stored in watertight silos designed to ensure that there is no loss in storage. The silos shall be emptied and cleaned every 6 months and whenever there is a change in the type or origin of the cement.

B. The cement supplied in bags shall be stored in a dry place, fully enclosed and covered, isolating them from the soil and from atmospheric agents. The store shall be of sufficient dimensions to allow easy access for identification, removal of samples, counting and moving the bags. The bags shall not be stored in piles exceeding 2.5 m in height.

C. The cement shall be used in chronological order of its arrival. The temperature of the cement at the time of its use shall not exceed 70°C.

D. The total storage capacity of the primary silos at site shall be sufficient to guarantee normal progress of works on site for a duration of 20 calendar days.

E. The use of any cement that has remained in storage on site for more than 4 months shall be subject to a complete series of physical tests to ensure that the specifications are complied with.

F. Any cement which has been exposed to the elements or which has set, even partially, or which has been rejected in compliance with the specifications shall not be used for the permanent Works and shall be removed from the silos or stores.

2.6 Cement Storage Record Book

The Contractor shall keep for every silo a cement storage record book in which the following will be noted:

1. The quantity of cement in store at the end of the week.
2. The quantities, origin and location of storage of the various batches delivered during the week.
3. The quantities used daily and the structures in which the cement is used.

2.7 Overall Quality of Aggregates

A. The aggregates shall be crushed material originating from rock that is neither sensitive to the environment nor likely to have any harmful effect with regard to the other concrete ingredients. Fine aggregates for concrete may consist of natural and/or crushed sand. Provenance of aggregates after washing, screening and possibly crushing is subject to prior Engineer's approval with evidence of their suitability as regards to the requirements of the present specification.

B. The aggregates shall meet the requirements of ASTM C 33 (but not limited to).

C. The density of the aggregates shall be greater than 2.56 t/m³.

2.8 Grading of Fine Aggregates

A. The fine aggregate shall be made up of two separate categories, which shall be:

1. Fine sand 0 - 0.630 mm
2. Coarse sand 0.630 mm - 5.0 mm

B. The grain size characteristics of the fine aggregate after mixing the two categories shall be within the following range, the material passing Sieve Number 200 (0.075mm) shall be =< 5%:

Sieve Designation (Specification E11)	Percent passing by weight
9.5 mm (3/8 in.)	100
4.75 mm (N°4)	95 to 100
2.36 mm (N°8)	80 to 95
1.18 mm (N°16)	50 to 85
600 µm (N°30)	25 to 60
300 µ m (N°50)	5 to 30
150 µm (N°100)	0 to 10

C.

1. The fineness modulus shall be within the range of 2.3 to 3.1.
2. The fine aggregate shall have not more than 45 % passing any sieve and retained on the next consecutive sieve of those shown in above Table.

2.9 Grading of Coarse Aggregates

A. The coarse aggregates shall be in line with Size Number 6 (nominal maximum aggregate size of 19mm) and 7 (nominal maximum aggregate size 12.5mm) according to ASTM C33.

2.10 Properties of Aggregates

A. General

Characteristic	Value	Test Method	Field of application
Water absorption, Ab	< 4 <2	ASTM C 127 ASTM C 128	Coarse aggregate Fine aggregate
Los Angeles, LA	< 30	ASTM C 131	Coarse aggregate
Flattening coefficient	< 30	NF P 18-561	Coarse aggregate
Sand equivalent SE	> 75	ASTM C 2419	Fine aggregate (Mixtures of natural and crushed sands)
Sulfate Soundness	< 12% < 10%	ASTM C88	Coarse aggregate Fine aggregate
Organic impurities	Color Plate No. 3 or less	ASTM C40	Fine aggregate

B. Sand equivalent

Fine aggregates having a sand equivalent (SE) which is less than the specified value may be accepted by the Engineer if the methylene blue value (MBV) measured according to standard AASHTO TP57 is less than 1 g per 1 kg of fines passing through the 75-micron sieve.

The material passing Sieve Number 200 (0.075mm) shall in no case exceed 3% by weight of the combined (all-in) aggregate.

The coarse and fine aggregates shall be tested by the Contractor (before/material submittal and during the execution) as directed by the Engineer for his approval, petrographic analysis may also be requested by the Engineer, if it is found necessary.

2.11 Transport and Storage of Aggregates

A. The transport and storage methods shall be such as to guarantee a stable and uniform water content and to avoid any segregation.

B. The different classes of aggregates shall be stored separately in silos or on a concrete platform or by any other means guaranteeing an equivalent level of cleanliness. The storage area must be designed to ensure effective drainage of the aggregates. The aggregates shall be stored sheltered from rain and protected from solar radiation.

C. The capacity of the storage specified in para. B for each class of aggregates shall be sufficient to ensure progress of work on the site for a duration of minimum 8 days.

2.12 Verification of Aggregates

A. Normal frequency N

1. Every week or every 500 m³ of concrete if the volume of concrete manufactured is less than 500 m³ per week.
2. For every new delivery of a material of different origin or obtained by a different process.

B. Frequency xN

1. Every x tests carried out at the normal frequency.
2. For every new delivery.

C. Tests to be performed on the aggregates (but not limited to):

Characteristics	Method ASTM	Field of application	Frequency
Grain size analysis	C 136	All aggregates	N
Water content	C 566	Fine aggregates	N
Water content	C 566	Coarse aggregates	N
Fineness modulus diagram	C 136	All aggregates	10 N
Water absorption	C 127	Coarse aggregates	5 N
Water absorption	C 128	Fine aggregates	5 N
Los Angeles	C 131	Coarse Aggregates	15 N
Organic impurities	C 40	Fine aggregates	10 N
Sand equivalent	D 2419	Fine aggregates	N
Soundness	C 88	All aggregates	15 N
Flattening Coefficient	NF P 18-561	Aggregates > 4 mm	5 N

D. The tests shall be performed on samples taken in accordance with the Engineer's instructions.

E. Diagram of fineness modulus

At the specified frequency, a series of 10 sieve analyses will be made at intervals of about 1 hour. The following will be noted on a diagram: the 10 results, the average of the 10 results, the straight lines situated at 0.10 and 0.20 unit above and below the mean value. The results of the fineness modulus determined by the normal sieve analyses shall also be shown on this diagram.

F. Methylene Blue value

Measurement of the methylene blue value (MBV) shall be made where the equivalent sand value (SE) is less than the specified value.

2.13 Water

A. The mixing and curing water shall be free of any impurities which might significantly affect the duration of setting, the strength or durability of the concrete or which might affect the appearance of the concrete by discolouration, coloration or efflorescence.

B. The mixing and curing water shall meet the following specifications (and/or specifications given in ASTM C 1602/C 1602M):

Impurity	Maximum content (part per million - ppm)
Suspended matter	2000
Carbonates and bicarbonates	1000
Sulphate (SO3)	1000
Dissolved salts	2000

C. Where the dissolved salt concentration exceeds the specified value, or where the water quality is doubtful in the Engineer's opinion, comparative tests of compressive strength and setting time will be performed on two cement pastes with the same cement, one with the water in question and the other the reference paste, with distilled water in the same proportions. The water will be acceptable if the test results comply with the following values:

Test	Limit	Standard
Compressive strength at 7 days minimum result compared to reference paste	90 %	ASTM C 349
Time of setting: deviation from reference past, h: minimum.	From 1:00 early to 1:30 later	ASTM C 191

D. Control tests shall be carried out:

1. For approval of the water.
2. For any change in the source of supply.

3. In any event, once every three months, or more often when there is reason to believe that a change has occurred in the characteristics of the source.

2.14 Additives

A. Additives shall comply with ASTM C 494 (and/or BSEN 934).

B. The use of additives containing calcium chloride is forbidden.

C. All additives shall be in liquid form.

D. Provision shall obligatorily be made for the automatic addition of any additive.

E. The concrete shall be made with addition of a water reducing plasticizer, with the exception of blinding concrete.

F. The Contractor shall submit, for approval of any proposed additive, a memorandum demonstrating, on the basis of test results, the compatibility of the additive with the other concrete ingredients, its influence on the proportion of water for equal consistency, its effect on consistency for equal proportions of water, the times of beginning and end of setting of the neat cement paste, and the mechanical strengths of the concrete obtained. These tests are performed for the optimum proportion proposed and for half and double of this optimum proportion.

G. Where specified, the following additives shall be used:

1. Air entrainer.
2. Shrinkage reducer for certain sealing grout or mortars; this additive shall be free of iron.
3. Setting accelerator for shotcrete.

2.15 Classes of Concrete

A. The concrete classes are defined by their characteristic strength fc in MPa, followed by the specified coarser aggregate dimensions in mm.

B. The characteristic strength fck is the compressive strength at 28 days on 150 mm dia cylinder for all concrete classes A, B, C, D, below which less than 5% of the tested samples should be found.

C. Classification table:

Class	Class according to BS EN 206-1 (Cylinder/Cube)	Definition	f_{ck} (MPa, minimum, Cylinder)	Coarser aggregate dimension (mm)	Cement content kg/m³		Max water/ Cement ratio max W/C
					min	max	
A	C35/45	Reinforced concrete Precast concrete	35	20	340		0.45
B	C20/25	Unreinforced and lightly reinforced concrete	20	20	260		0.65
C	C16/20	Blinding concrete	16	20	200		-
D	C12/15	Porous concrete	12	37.5	200		-

2.16 Concrete Composition

For each class of concrete, a memorandum shall be submitted to the Engineer demonstrating that for the design consistency, the proposed composition and the installations on site will produce concrete satisfying the specifications.

If the proposed concrete has not been made previously from materials of the same type and origin and with equivalent site installations, a concrete design study shall be made for testing, with the exception of blinding concrete.

2.17 Concrete Design Study

A. Purpose

1. Check that the nominal composition of the concrete proposed by the Contractor enables the specification to be met.
2. Check that the concrete specifications are still respected if the quality of the ingredients reaches the specified limits or the probable limits of the ingredients used.
3. Check that the concrete specifications are still respected if the proportions of the ingredients reach the specified limits or the probable limits resulting from the site installation (the design limits may also be chosen so as to study several nominal compositions simultaneously).

B. The design test will involve the following operations:

1. Three batches meeting the nominal formula.
2. Eight batches varying from the nominal formula as follows:
    a) Two batches by modifying the proportions of aggregates (for example variation of the ratio of the mass of coarse aggregates to that of finer aggregates by 10% in either direction).
    b) Two batches by altering the quantity of mixing water (10 l/m³ more and less).
    c) Two batches by altering the quantity of cement (25 kg/m³ more and less).
    d) If an additive or additives are used, two batches by altering the quantity or quantities of additives (half and double the optimum quantities).

C. Measurements made for concrete classes A, B and C:

1. Each batch shall be the subject of the following measurements:
2. consistency;
3. density and air content within the fresh concrete;
4. density of concrete at 28 days;
5. compressive strength at 7 days on three samples;
6. compressive strength at 28 days on three samples and static modulus of elasticity and Poisson's ratio (in addition to ASTM C 469 strains shall be measured for stresses of 3, 5, 7, 9, 11 MPa).
7. The components shall be subject to the control measurements specified elsewhere.
8. Also to be noted are the following factors:
    ~ Temperature of the components and of the concrete during the tests.
    ~ Aspect of the fresh concrete during performance of the consistency test and of the preparation of the specimens.
    ~ Aspect of breakage during the mechanical tests.

D. Interpretation of the design test:

1. The design test shall be considered valid and the composition of the concrete accepted if all the following conditions are met:
    a) All consistency results are within the specified ranges.
    b) The arithmetic mean (fcE) of the 9 measurements (3 tests on each of 3 batches) of compressive strength in MPa measured at 28 days is greater than:

fc + (CE Cmin)

and greater than 1.1 fc,

formula in which CE is the compressive strength at 28 days of the cement used for the design test and Cmin is the minimum guaranteed value of the cement's compressive strength at 28 days.

c) The arithmetic mean of the 3 compressive strength tests on each of the complementary batches is within the range of fcE ± 0.15 fcE.

2. If the above conditions are not totally satisfied but the concrete is close to the required values or well in excess of these values, the Engineer may accept the nominal composition of the concrete, or may ask for further design test.

2.18 Concrete Suitability Tests

A. The suitability test, to be performed on the site at least 40 days before making any concrete for the permanent Works, shall be aimed at verifying the following:

1. that the concrete made by applying the nominal composition, using the materials and constructional plant delivered to the site, satisfies the specifications,
2. that the concrete composition, considering the installations it is envisaged to use, will enable the structures to be built in a satisfactory manner,
3. that the characteristics of the plant (Certificate of Conformance and Calibration Reports) are in conformity with those submitted to the Engineer's approval.

B. The suitability test, performed under conditions representative of the site (transport, installations and plant used, temperature, etc) implies the making of three batches to the nominal composition and will involve:

1. Casting of a reference concrete sample in representative formwork, where required by the Engineer.
2. Casting of a volume of 1 m³ of concrete.
3. Performance of the same sampling and tests as for the design test.
4. Verification of the characteristics of the site installations or the materials supplied.

C. The test shall be interpreted on the same basis as the design test.

2.19 Concrete Consistency

A. The consistency of the concrete shall be such that it can be placed using the site facilities and compacted so as to enclose completely the reinforcement bars and embedded parts and completely fill the formwork, with neither voids nor segregation.

B. Consistency shall be checked by measuring the slumps test (ASTM C 143).

C. For concrete with aggregate larger than 37.5 mm, the test shall be performed on the fraction of concrete passing 37.5 mm sieve (the larger aggregate being removed in accordance with ASTM C 172).

D. The consistency shall be specified as target slump, and the target values as well as tolerances for fresh concrete in different conditions, shall be according to BS EN 206.

E. The Engineer reserves the right to specify different consistencies/slumps where required by the nature of the works.

F. The concrete consistency/slumps shall be measured at the time it is used at the Engineer's discretion. If the measurement made falls outside the specified limits, two control measurements

shall be made immediately, and the result shall be taken as the average of the three measurements, rounded off to the nearest centimetre.

G. In case of sampling for testing the strength of the concrete, 3 measurements shall always be made.

2.20 Special Specifications for Porous Concrete

A. Porous concrete is one containing no sand (or little sand 5 to 7 percent for freeze–thaw durability), used for drainage purposes under structures.

The Engineer shall be responsible for defining whether or not it is to be used, even it is not shown in drawings.

B. Composition

Porous concrete is characterised by the minimum cement content in kg/m³, the maximum dimension of the aggregates □max in mm and the characteristic strength fc in MPa measured on 16 x 32 cm cylinders.

Category	Minimum cement content (kg/m³)	ϕ_{max} (mm)	f_c (MPa)
I. Porous concrete	200	37.5	12

The characteristic strength fc is the 28-day compressive strength below which less than 5% of the samples should be situated.

No sand shall be used, unless requested by the Engineer.

2.21 Particular Specification for Blinding Concrete

A. The blinding concrete refers to a base layer of relatively weak concrete that is laid above the non-rock foundation to provide a clean, levelled and dry working surface.

B. The concrete shall be obtained from a mix of fine aggregate, coarse aggregates and cement at 260 kg minimum per m³ of concrete. The exact composition shall be proposed by the Contractor for C20/25 class of concrete.

2.22 Concrete Mixing

A. The aggregates, water, cement and additives shall be mixed in an automatic concrete mixer with batching by weight, equipped with:

1. a wattmeter (slumpmeter or any other approved concrete workability meter),
2. a printed register for recording the date and time of batching, the weight of cement and aggregates and the water cement ratio and class of concrete.
3. A continuous moisture measuring device for sand.

B. The output of the plant shall be adapted to the programme of work and shall be at least 100 m³/hour.

C. After the concrete has been mixed, no subsequent addition of water in the course of concreting will be tolerated.

D. The mixing operation shall be under the control of a suitably experienced supervisor.

E. The sequence of filling a mixer with the concrete ingredients shall be studied during the suitability tests and subject to the approval of the Engineer and unless otherwise authorized, the same sequence of filling shall be followed throughout the work.

F. The quantity of mixed materials per batch shall not exceed the manufacturer's rated capacity of the mixer, and shall be further reduced for fluid concrete.

G. An automatic timing device shall be used to set the duration of mixing.

H. Mixing time shall be adjusted according to mix compositions and the mixers used and shall be at least 45 s after all components have been added. In the case of concrete containing admixtures, a minimum mixing time of 60 s shall be observed.

I. At intervals decided by the Engineer, but which normally be once per day for coarse aggregates and at some other interval depending on the operation of the continuous moisture measuring device for sand, the Contractor (or approved concrete batching plant) shall carry out tests by an approved method to determine the free moisture content of the aggregates. Based on these tests, adjustments shall be made to the quantity of water added to the mix to maintain the specified water cement ratio.

J. On commencing work with a clean mixer, the first batch shall contain only half of the normal quantity of the coarsest aggregate category and 10 % extra cement so as to compensate for the fine material and cement which is left sticking to the drum. This batch shall be mixed for at least one minute longer than normal.

K. The mixer shall be completely emptied before being charged with the materials for the succeeding batch.

L. Weight tolerances:

1. Cement and water: .....± 2%
2. Aggregates:
   - Sand .....± 3%
   - Coarse aggregate.....± 5%
   - Total of the aggregate .....± 3%
   - Admixture:.....± 5%

M. Checking of weighing scales

The precision of the weighing scales of the batching plant shall be checked at the beginning of each month.

If the precision falls outside the specified tolerances, the batching plant shall not be used again until the scales have been adjusted or repaired as necessary.

N. Mixer performance

Mixer performance shall be determined in accordance with ASTM C 94 to determine the uniformity of the mixture.

3 EXECUTION

3.1 Inspection

A. No concreting shall start until issue by the Engineer of a 'concrete permit'.

B. The Contractor shall request this permit at least 24 hours before the presumed start of concreting and after checking that the parts designed to be embedded in the concrete (reinforcement bars, waterstop joints, tie rods, etc) and the formwork are correctly placed and fixed and that all surfaces designed to be in contact with the concrete have been prepared. The checking before concreting will also include for the dam, water circulation through the watertight coiled pipes, as well as the resistance of these pipes to pressure in excess of the maximum service pressure.

3.2 Preparation

A. Before casting any concrete layer, the surface of the previously cast concrete shall have been subjected to treatment consisting of the following operations:

1. Grout shall be removed from the surface, so as to reveal the mosaic of the concrete, without dislodging the coarser aggregates, nor the reinforcement bars or other embedded parts. Where possible, treatment shall be effected after the concrete has set but before hardening, using either a water jet under pressure or a mixture of air and water under pressure, alternatively by brushing the surface with a wire brush. Where this treatment is precluded by the hardening of the concrete, the surface shall be treated either by high pressure water jet or by sand blasting, or by scabbling the surface. In case of scabbling, the fissured or loosened pieces shall be removed
2. Cleaning with water and air under pressure.
3. Moistening for a minimum duration of 24 hours before concreting.
4. Elimination of excess water and final cleaning.

B. Before placing concrete on the rock or common soil, the foundation surfaces shall be prepared as indicated under Section 02210.

3.3 Concrete Placing

A. Concrete shall be transported from the mixer to its final position in such a manner that the concrete as placed shall not have lost excessive moisture or grout, nor become segregated.

B. The concrete shall be placed and compacted in a such a manner as to avoid any movement of formwork, reinforcement bars, embedded parts or parts to be embedded.

C. If required by the Engineer, the first layer of fresh concrete placed on hardened concrete shall consist of a mix which is the same as that of the new lift but without the larger nominal category of coarse aggregates. This layer shall be between 4 and 10 cm thick as directed and shall be covered before it has started setting.

D. On rocky surfaces, immediately before concreting, a 5 cm thick layer of mortar shall be placed over the entire surface and in any fracture joints, so as to ensure an effective rock concrete bond. The necessary arrangements shall be adopted to cover this mortar with concrete before it has started setting.

E. The necessary arrangements shall be taken to ensure that all waterstop and other embedded items are effectively well covered by concrete and that they are not subject to any movement compared to their theoretical position.

F. Qualified personnel shall be included in the concreting team to apply the appropriate remedial action in case of any incident such as movement of forms, steel bars, joints, drains, ducts, grouting valves, grouting groove protection, etc.

G. The Contractor shall provide a means of direct communication between the concrete batching plant and the location of concreting (telephone or radio telephone).

H. In case of simultaneous placing of different classes of concrete, the Contractor shall provide a system of identification which will follow each concrete until it is placed.

I. The concrete shall be poured as close as possible to its final position. The concrete shall be moved within the formwork by shovel and not simply by flow induced by vibration which is forbidden. Any accumulation of gravel shall be dispersed within the mass of the concrete. Any water shall be removed as and when it appears.

J. Within each lift, concreting shall be effected in successive layers not exceeding 50 cm in thickness, unless otherwise stipulated by the Engineer.

K. For massive concrete structures, the lifts shall not exceed 2.50 m in height. The time interval between completion of one lift and starting the next shall be at least 72 hours. The height of these lifts and the time elapsed between successive lifts may be modified depending on temperature changes recorded in the concrete already cast, as compared to the specified temperatures.

L. Before it is covered by a new layer, each layer shall be fully compacted but shall not have begun to set.

M. All concrete shall be compacted by internal high frequency vibrators. The number, size, frequency and power rating of the vibrators shall at all times be adequate to obtain appropriate and rapid compaction of the entire volume of concrete to be placed. A third of the required number shall be kept available for use no more than 15 min from the location of compaction.

N. The vibrators shall be introduced vertically at regular intervals within the concrete to be compacted. If the layer being placed covers a freshly compacted layer, the vibrators shall be introduced to a depth of about 10 cm in the preceding layer. The vibrators shall be withdrawn slowly, so as not to allow the formation of any void.

O. Vibration shall continue until the rise of air bubbles has practically stopped, and shall be stopped as soon as laitance or excess water appears.

P. The vibrators shall not be inserted into the concrete hazardly or irregularly, nor used to move the concrete from one point to another within the formwork. The vibrators shall not enter into contact with the reinforcement bars nor with the formwork.

Q. Where use of external vibrators is agreed, they shall be securely clamped to the shutters to ensure maximum efficiency.

R. Where the presence of air bubbles is prejudicial to the structure, the thickness of the layers shall be reduced, and additional compaction shall be effected along the formwork, after the regular compaction of the overall concreted area.

S. If in the course of placing concrete, it may become necessary by reason of an unavoidable breakdown of plant or for other reasons accepted by the Engineer, to interrupt concreting and if the concrete has taken its initial set, the surface of the concrete shall be treated as a construction joint.

3.4 Concreting In Hot Weather

A. When the daily maximum temperature exceeds 35□C, concreting shall take place at night time, unless special arrangements are adopted for mixing, transport and placing of the concrete.

B. These particular arrangements could include:

1. Spraying of gravel and pebbles.
2. Cooling of water.
3. Spraying of formwork.
4. Protection of the concrete during transport and placing against solar radiation.
5. Use of ice in mixing water.
6. Painting water tanks with reflecting paint.

C. In all cases, the temperature of the concrete when it is placed shall be less than:

1. 28°C for massive structures, i.e. structures with a thickness more than 0.60 m.
2. 32°C for other structures of which the thickness is less than 0.60 m.

3.5 Concreting in Cold Weather

1. In cold weather concreting may take place only if the following precautions and provisions are rigorously observed.
2. Suitable means shall be provided to warm the aggregate and/or mixing water, or otherwise to ensure that the temperature of the concrete leaving the batching plant shall not be lower than 100C. Aggregates, cement and mixing water bearing or containing ice shall not be used and no ice shall be present in any mixer, hopper, skip, vibration or other apparatus in contact with the concrete. Mixing water shall not be heated above 60oC. Salt or chemicals including proprietary accelerators or hardeners shall not be mixed with the concrete for the purpose of preventing freezing or accelerating hardening unless permitted by the Engineer.
3. Concrete when deposited shall have a temperature of not less than 5oC. Suitable precautions shall be taken to ensure that the temperature of the concrete after placing does not fall below this temperature until it has thoroughly hardened.
4. In putting forward his proposals for concreting in cold weather, the Contractor shall have regard to the recommendation contained in "Winter Concreting" as published by the Cement and Concrete Association, 52 Grosvenor Gardens, London SW1, UK.
5. If the Engineer is not fully satisfied with the Contractor's arrangements, no concreting shall take place when the shade temperature is below 20C or if there is any prospect of frost within 24 hours.
6. The Contractor shall provide and keep available for the Engineer's use a thermometer suitable for measuring the temperature of aggregates and ready-mix concrete delivered to site and a maximum and minimum thermometer which shall be hung in a position approved by the Engineer.

3.6 Concreting in Wet Weather

During wet weather, all necessary tarpaulins, baffles, diversion channels, etc., shall be laid to protect areas prepared for concreting and/or newly placed concrete from heavy rain and run-off. Surfaces on or against which concrete is to be placed shall be protected from becoming excessively wet prior to concreting.

3.7 Curing of Concrete

A. Exposed concrete surfaces shall be kept damp by one of the following methods:
   1. Covering horizontal surfaces with a layer of sand, hessian or other absorbent material maintained in a damp condition.
   2. Continuous watering, maintaining a flow of water over the concrete.
   3. After watering, covering of the surface with an impermeable membrane.
   4. Application of a curing compound.

B. The use of a curing compound will not be permitted for surfaces which will receive a further concrete lift without any further preparation and for surfaces whose aspect may be affected by the curing compound.

C. Curing shall commence as soon as possible after placing of the concrete for unshuttered parts and immediately after removal of formwork in other cases.

D. Curing shall be continued for a period of 14 days unless otherwise agreed by the Engineer.

E. Underground concrete shall not require curing when the relative humidity of the air is higher than 75%.

3.8 Second Stage Concrete for Sealing Embedded Parts of Equipment

A. Placing of second stage concrete shall not proceed until embedded parts have been completely assembled, aligned and secured.

B. Constant caution shall be exercised in placing concrete to avoid distortion and displacement of parts being embedded.

C. The workability (including slump) shall be sufficient to achieve satisfactory pouring in the interstices of the first stage concrete.

D. A controlled expansive admixture from an approved manufacturer shall be added (if needed). The admixture shall be mixed in accordance with the manufacturer's instructions. Prior tests shall be conducted before final approval can be given by the Engineer to adjust the amount of admixture to obtain. Cast iron powder admixture shall not be used in contact with high tensile steel nor in direct contact with water.

E. For small holes (section less than 1 dm^2), mortar shall be used. The mix shall be 450 kg of cement per cubic metre of sand with the addition of an approved controlled expansive admixture (or equivalent dry-ready-mix, as directed by the Engineer).

F. Interface between the first and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.

G. Interface between the equipment and the second stage of concreting shall have a watertightness equivalent to construction, contraction and expansion joints.

H. Formwork shall be perfectly connected with the first stage concrete; irregularities shall be made good by means of grinding.

3.9 Precast Concrete

A. The working drawings may provide for certain parts of structures to be made from precast elements but, for ease of execution, the Contractor may ask to precast other parts of structures not initially indicated as such.

B. The Contractor shall submit clear details of the casting and placing procedures that he intends using as well as his planned arrangements for the precasting yard. Precasting work can start as soon as the Engineer has given his approval of the foregoing details and arrangements.

C. Precasting shall be organised in such a manner that:

1. Precast parts are always kept away from sunlight.
2. Precast parts are not handled for a period of 8 days after casting, unless concrete strength tests indicate the possibility of handling the parts within a shorter time.
3. All parts from the same mould are stored together.
4. No stored part shall be subjected to any load other than its deadweight.
5. Precast parts are installed in their final positions no earlier than 21 days after casting, unless concrete strength tests indicate the possibility of reducing this time.

D. The casting date and part references (or mould number) shall be written on each part in the fresh concrete.

E. Faces in contact with covering concrete after placing shall, if necessary, be treated as concrete construction joints; this clause shall be especially applicable in cases where intermediate slabs are used, the restarting surface of which must be treated accordingly.

3.10 Concrete Shuttering Underground

A. Such concrete shall be placed mechanically unless otherwise approved by the Engineer.

B. Inflowing water shall be collected and piped to a dewatering system before executing any lining concrete.

C. Arch keying shall be carried out as accurately as possible and, in any case, shall meet the minimum lining thickness requirements. Unless otherwise specified on drawings or approved by the Engineer, the minimum thickness requirements is the thickness of the concrete between the 'A' line and the exposed surface of the concrete. Keying shall be checked by exploratory drillings made at the Engineer's request.

D. The concrete shall be compacted using external vibrators and completed using internal vibrators inserted inside the formwork through windows. The number and size of these windows shall be sufficient to vibrate the concrete under optimum conditions.

E. Closure of these windows shall be made watertight.

F. Unless explicitly authorised by the Engineer, no timber supports shall be incorporated in the final lining.

3.11 Blinding Concrete

A. Blinding concrete shall be used when the structural concrete is in contact with a non-rock foundation.

B. The final mean thickness shall be 10 cm and never less than 5 cm.

C. Blinding concrete shall cover the entire area to be concreted.

D. The Contractor shall arrange for the recovery and elimination of all infiltrating water so that there is no risk of the concrete being washed out.

3.12 Wear-Resistant Concrete

A. The Contractor shall propose special micro-concrete of the Lafarge "Alag" type or similar with high adherence, abrasion-resistance and shock-resistance characteristics at places where this is necessary as defined on the drawings (or as directed by the Engineer).

B. A complete file containing the characteristics of the products and details of the procedure to be used shall be submitted to the Engineer for approval.

C. In all cases, the following minimum procedure shall be followed:

1. Floor reinforcements shall be placed at a minimum of 10 cm from the finished surface with a tolerance of +2 cm and -0 cm.
2. Pouring of primary concrete shall take into account the thickness of the wear-resistant concrete, i.e. 8-10 cm from the finished level (rebars must be embedded by at least 2 cm).
3. The top surface must be cleaned with air and water under pressure before it has completely set, or by high-pressure cleaning after it has set.
4. The support must be completely saturated (24-48 hours).
5. Wear-resistant concrete is poured and thoroughly vibrated in chequerboard 2 m x 2 m slabs during stage 1 (class 1 surface quality).
6. The concrete is kept moist after it has begun to set (by spraying or by using a curing agent).
7. The stage 2 slabs are cast after a minimum period of 24 hours.

3.13 Deposition of Concrete on Foundations

A. The Contractor should keep free of running water and pools the surface of rock upon or against which concrete is to be deposited. Fissures or seams in the rock shall be cleaned out to a depth

satisfactory to the Engineer and if necessary, stemmed with cement mortar (or grout) of an approved mix. The rock surface will be inspected by the Engineer before concreting starts.

B. For deposition of concrete on earth/soil/soil-like foundations the surface of foundation shall be levelled out before concreting, a layer of blinding concrete shall be disposed on all the surface in contact with the concrete structure and the concreting may start after approval by the Engineer.

C. The blinding concrete layer shall not be less than 5 cm thick.

D. For hydraulic structures the concrete foundations shall be placed over and/or aside an adequate filter sufficiently drained, as specified by the Engineer.

3.14 Concreting Construction Joints

A. The location of concrete construction joints, other than joints shown of the Drawings or specified, shall be approved by the Engineer; concrete shall be placed continuously between joints.

B. Duration between the two stages of concrete for a construction joint shall be approved by the Engineer.

C. All construction joints shall terminate against firm shuttering. All necessary steps shall be taken by means of timber edgings, etc. to ensure an exact finish to edges of joints which are exposed to view.

D. Before placing concrete against concrete which has already set at a construction joint, the surface of the previous concrete shall be prepared by the following methods. If the preparation is carried out before the previously placed concrete has hardened, the surface shall be cleaned with water and air at 5 kg/cm² pressure to expose the coarse aggregate. If the concrete has hardened the surface shall be scabbled at least 2 cm deep and cleaned in such manner that no loose particles of aggregate or damaged concrete remain on the surface. In all cases the surface shall be thoroughly cleaned with an air and water jet at 5 kg/cm² pressure to remove all laitance, scum and foreign matter. The surface shall be wetted before placing new concrete against it.

E. Construction joints shall be so located and the amount of concrete placed at any one time shall be so limited in size and shape as to minimise shrinkage and temperature effects.

3.15 Concreting Movement Joints

A. Joints between concrete surface is not intended to bond together (contraction joints) shall have the first formed surface painted with two coats of bituminous paint (as noted in drawings), the second applied after the first has thoroughly dried or according to the instructions of the Engineer.

B. Waterstops shall be fixed with at least 5 cm clearance from any reinforcement bar, accurately positioned as shown on the Drawings and tightly fixed in the shutters before concreting starts. Connections shall be made to ensure watertightness and all precautions taken for careful concreting around the waterstop.

C. No nail shall be driven through any part of a waterstop for fixing. Any waterstop punctured or torn to any extent shall be replaced before concreting.

D. Shuttering of the first concreted surface of the joint shall be placed carefully perpendicular to the surface of the structure. Waterstops shall be placed carefully on a straight line and perpendicular to the surface of the joints, and/or according to the shape shown on the Drawings or instructions of the Engineer.

E. Particular care shall be taken with the protection of the outer part of waterstops half embedded in the structure and awaiting completion.

F. In the event of excavation in the vicinity of the waterstop or when more than one-month elapses before completion of the structure, a protection device such as a wooden box shall be provided by

the Contractor. Rubber waterstops shall be stored in as cool a place as practicable and in no case shall they be exposed to the direct rays of the sun.

G. All joint implements such as waterstops, joint fillers, sealing compounds, etc. shall be handled and settled in accordance with the instructions given by the Manufacturer. All related notices and instructions shall be furnished to the Engineer prior to any approval being given.

H. Compressive filler (flexcell, or equivalent)) when placed against concrete faces shall be fastened with adhesive before concreting of the next element.

I. When required, the joints shall be sealed with concrete mortar containing 450 kg of cement per cubic metre of concrete mortar containing admixture if requested by the Engineer (or dry-ready-mix as directed by the Engineer). The edges of the grooves shall be previously carefully watered and cleaned with a brush to remove any foreign bodies. Then the grooves shall be filled with mortar, compacted and surfaced and dressed by handwork. Immediately after completion, the joint shall be protected against the sun and regularly sprinkled with water as requested by the Engineer.

3.16 Finishing of Non-Shuttered Concrete Surfaces

A. The Contractor shall be responsible for finishing non shuttered concrete surfaces as soon as concrete placing has been completed and before hardening.

B. Surfaces shall be finished using a simple screed, a vibrating screed, a float, etc. or by any other means enabling the required quality to be obtained. Screed guiding devices and supports shall be submitted for the Engineer's prior approval.

C. Surfaces shall be provided with a slope to allow water to drain off, as provided for on the drawings or as instructed by the Engineer.

3.17 Inspection Test and Acceptance of Concretes Classes

A. Definitions

1. Lot: a lot of concrete is a structure or part thereof or set of structures or parts of similar structures cast in a single lift using concrete of the same class.
2. Sampling: a given sampling is effected on a single batch and one batch can give rise to only one sampling.
3. Result: a result is the average of the measurements made on all the samples taken for a given sampling (generally three).

B. Sampling frequency

1. The number of samplings made shall be as follows:
    a) Mass concrete (Class B)
        1. one for a lot of less than 500 m³
        2. two for a lot of more than 500 m³
    b) Other concrete (Class A)
        1. one for a lot of less than 50 m³
        2. two for a lot of 50 to 250 m³
        3. three for a lot of more than 250 m³
2. The sampling frequency shall be greater at the beginning of the works in order to make sure of quality levels as quickly as possible, and during periods when, in the Engineer's opinion, quality is considered doubtful.

C. Tests to be carried out

1. The following tests shall be carried out for each sampling:
    a) Three samples 160 mm dia cylinder for determination of compressive strength after 28 days (ASTM C 39).
    b) One measurement of air content (ASTM C 231).
    c) One consistency measurement (ASTM C 143).
    d) One temperature measurement.

   Additional tests may be required by the Engineer, especially when the concrete consistency varies to a significant extent.

2. On average every three samplings and in accordance with instructions given by the Engineer:
    a) Three samples for determination of the compressive strength after 7 days.
    b) Three samples for determination of the tensile strength after 28 days (ASTM C 496).
3. On average every 30 samplings and in accordance with instructions given by the Engineer, 12 samples for determination of modulus of elasticity, compressive and tensile strength after 90 and 365 days (six after 90 days and six after 365 days).
4. All samples shall be taken at the time and on the site of concrete placing.

D. Concrete acceptance criteria

1. A lot shall be deemed to conform to specifications when the following conditions are satisfied:
    a) Consistency: the test result(s) come within the specified tolerances.
    b) Compressive strength after 28 days:
        1 Each result is higher than 0.85 fc
        2. In the event of three or more samplings from a lot, the average of the results is greater than fc.
2. A concrete of a given class shall be deemed to conform to the specification when the average of any 3 consecutive results (not necessarily from the same lot) is higher than fc.

E. Use of 7-day and 28-day test results

For each class of concrete, the results of all the tests shall be used to establish a "least-square" line of best fit to define the relationship between test results and the age of the concrete. The relationships shall be continuously updated during the period of the Contract, and shall be used for the initial assessment of 90-day strength from 7-day and 28-day strengths, or the initial assessment of 28-day strength from 7-day strength.

F. Ready mix lorries

The concrete in each ready-mix lorry shall be checked for uniformity within the context of the concrete suitability tests and then every quarter according to ASTM C 94. If concrete uniformity is not satisfactory, one of the following measures will be taken until the specifications are met:

1. Increase in mixing time.
2. Reduction in quantity of concrete transported.
3. Modification of ready-mix lorry.

In addition to above, BS 5328 shall also be taken into account in rate of sampling for conformity testing.

3.18 Testing for Watertightness of Reinforced Concrete Reservoirs

On completion of the works, the reservoirs shall be tested for watertightness when filled with water, before backfilling around the reservoirs and before applying coating or facing on external face of walls.

Each reservoir shall be filled slowly with a rate of 1.50 m (rise of water level in 24 hours, up to top water level). Before testing a period of 10 days will be necessary for the initial soakage and every day water will be added to raise the water level to its initial level. It will have to make clear that the level drop decreases each day.

Water for tests shall be provided by the Contractor. The Contractor shall provide all necessary equipment to transfer the water used for tests from one reservoir to another to be tested.

When the soakage period has been completed, the test shall be started by refilling the reservoir to top water level and accurately recording the level each day over a period of seven days. The evaporation shall be checked by fixed in the reservoir a steel tank filled with water. Any drop in level in the steel tank will then be considered as evaporation loss. The structure will be deemed to be watertight if the total loss of water does not exceed 0.5 l per day and per square meter of wet concrete face.

The reservoir shall not be finally accepted as satisfactory until all leakages exceeding this value have been eliminated by treatment with appropriate products and with pressure grouting techniques. In this eventually, the treatment shall be approved by the Engineer and the Contractor shall repair at his own expense any leak involved.

From the time a reservoir is accepted, the Contractor shall keep the interior in wet conditions until commissioning of reservoir. This can be assessed by keeping a minimum water level inside each accepted reservoir, or any other mean approved by the Engineer.

Just before commissioning, each reservoir shall be emptied and disinfected according to a methodology proposed by the Contractor and approved by the Engineer.

In addition to above, reservoirs may also be tested for liquid retention according to BS8007 after taking the approval of the Engineer.

3.19 Action In the Event of Non-Conformance (For Concrete Classes)

A. If the consistency of the concrete is outside the nominal tolerance by inside the maximum tolerance, the composition of the fresh concrete shall be checked immediately, in particular the water content of the aggregates and quantity of water in the concrete. The Contractor shall make all necessary adjustments to recover the right consistency.

B. If the consistency of the concrete is outside the maximum tolerance, the concrete shall be rejected.

C. If the 28-day test results assessed from 7-day test results is abnormally low the Contractor shall stop concreting, establish the reasons for the strength decrease and take the necessary remedial action.

D. If the 28-day test confirm the assessment from 7-day test that the characteristics of concrete do not conform to the Specifications the volume of concrete represented by the samples shall at the discretion of the Engineer be subject to one or more of the following provisions:

    1. Cores from the suspected portions of the structure shall be drilled and tested in accordance with BS 6089 to determine whether the equivalent cylinder strength of the in-situ concrete satisfies the specified strength requirements.

    2. If the results of test on the cores taken in terms of (1) indicate that the concrete does not satisfy the specified requirements, the Engineer will decide whether or not full-scale load tests or an ultrasonic pulse velocity investigation may be carried out.

3. If in the opinion of the Engineer, the load tests are impracticable, or if a tested portion of the structure fails to pass the tests the Contractor shall, on the instructions and directions of the Engineer, and if possible, strengthen by approved means each section that failed or which contains concrete that failed, as relevant and also any other section, irrespective of strength requirements, the functional purpose of which is affected.
4. The works shall be demolished and reconstructed at the Contractor's expense, if the reinforcement or strengthening of the structure is not possible.

E. If it is found during concreting that the coefficient of variation of 28-day test results for a particular class of concrete is less or more than 14 percent, the Contractor and the Engineer shall meet to decide on the necessary reduction or increase respectively in cement content required to maintain the nominal strength of the concrete with the specified rate of failure. The reduction or increase in cement content shall be to the Contractor's account if this is attributable to him.

Note: The seven (7) day compressive strengths shall not be less than sixty-five (65) percent of the required twenty-eight (28) day strength

SECTION 03611
CONCRETE PIPES

1 GENERAL

1.1 Work Included

All concrete pipes covered by the present Contract.

1.2 Related Work

a) Section 02220 – Embankment, fill and backfill

b) Section 03200 – Reinforcements

c) Section 03300 - Concrete

1.3 Quality Assurance

Pipes shall bear:

1. The manufacturer's references.
2. The category and strength class to which they belong.
3. The date of manufacture.

1.4 Codes And Standards

A. Standards

- NF P 16 341: Drains, sewerage - Circular reinforced and unreinforced concrete pipes for unpressurised sewerage networks - Definitions, specifications, testing methods, marking, acceptance conditions.
- NF EN 681-2: Rubber seals - Specification for materials for joint seals on pipes used in the field of water and drainage - Part 2: thermoplastic elastomers.
- NF EN 640: Reinforced concrete pressure pipes and pressure pipes with reinforcement (with no metal web), including joints and fittings.
- ASTM C76 and AASHTO M170

B. Regulations

Section 70 of the French General Technical Specifications: sewerage pipes and ancillary structures.

1.5 Submittals

a) Engineer's approval file concerning the supplies: before any delivery is made, the Contractor shall submit to the Engineer for approval a file containing the following:

1. The characteristics, type, dimensions and masses of pipes and fittings.
2. The manufacturing processes.
3. The testing, marking and inspection methods.
4. The results of specified or standard tests.

b) Samples: before any delivery is made, the Contractor shall submit to the Engineer for approval a sample of the pipes and fittings.

c) Memorandum containing details of the transport, storage, handling and placing methods and a test programme for the pipes and fittings.

d) The results of inspection tests.

1.6 Description

Concrete pipes shall be used only for clarified water and in gravitary flow conditions.

1.7 Delivery, Storage and Handling

a) The Contractor shall follow the manufacturer's recommendations with regard to handling and storage.

b) Pipes shall be handled with equipment that will not cause damage, in particular to their ends.

c) It is forbidden to introduce slings inside the pipes.

2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1 Concrete

If pipes are manufactured on site, the concrete shall comply with the specifications of section 03.300 - Concrete.

2.2 Reinforcements

a) Reinforcements shall comply with the specifications of section 03200 - Reinforcements.

b) Reinforcements shall be covered by at least 20 mm of concrete or a thickness equivalent to the size of the largest aggregate if this value is higher (standard NF EN 640) or according to ASTM C76.

2.3 Joints

a) Joints shall be flexible and made exclusively with elastomer sealing rings (NF EN 681-2).

b) Joints shall be watertight under an angular variation of 2% and test pressure as specified by the corresponding standards.

2.4 Manufacture

Pipes shall be manufactured mechanically by a process ensuring that the concrete is highly compacted (radial compression, vibration, centrifuging, etc.) and that reinforcements have the specified cover.

2.5 Manholes

Manholes required at pipe junctions for inspecting, maintaining and possibly dismantling the various items of equipment shall be made of formed and reinforced concrete. Whenever the bearing capacity of the ground is insufficient, they shall be placed on concrete foundations.

Unless indicated to the contrary (or shown in drawings),, manholes shall be of square section, with the inside dimension being at least equal to the diameter of the largest pipe + 0.40 m, and with a minimum value of 1.20 m.

All formwork, reinforcements and concrete used for manholes shall comply with sections 03.100, 03.200 and 03.300 respectively of the present specifications.

A cast iron cover/grating, ND 800 mm (or as shown/noted in drawings),, shall be fitted to each manhole.

Aluminium ladders shall be provided to reach the bottom of the manhole + 0.80 m.

Manholes shall be designed to withstand a live load of AASHTO H-20 Truck Traffic, and they shall be in line with ASTM C497-19a.

2.6 Manufacturing Tolerances

a) Tolerance on useful length: .....±1%.

b) Tolerance on inside diameter: .....±10 mm

c) Tolerance on thickness: .....± 3 mm + 2% of thickness.

d) The inside surface of pipes must be smooth.

2.7 Checking - Acceptance

a) The appearance and marking of each pipe shall be checked.

b) Per batch, for each series:

1. Watertightness test under a pressure of 0.1 MPa for 30 mins on two pipes assembled with a deflection of 2%.
2. Crushing test (three-edge-bearing method), on one pipe.
3. Checking of geometric characteristics, diameter, thickness, useful length, eccentricity.

c) Batching: for each series of pipes and each type of test, the number of pipes tested shall be equal to the cube root of the number of pipes. At least one pipe shall be tested.

d) Acceptance: Watertightness shall be in conformity with standard NF 16 341. Traces of damp shall not be considered as defects justifying the rejection of the supplies.

2.8 Repairs

Repairs permitted by the Engineer shall only be made with epoxy mortar. If not, the pipes concerned shall be rejected.

3 EXECUTION

3.1 Inspection

a) Pipes and joints shall be checked by the Engineer before final placing in the trenches.

b) No pipe or pipe bed shall be laid until it has been approved by the Engineer.

3.2 Preparation

The pipe bedding material shall be spread uniformly over the entire width of the trench and adjusted in compliance with the levels and gradients indicated on the drawings.

3.3 Implementation

A. Laying pipes in trenches

1. When they are placed, all pipes and fittings shall be free of any foreign bodies that may have been introduced.
2. Pipes shall be lowered carefully into the trench and presented in line with one another. Wedging with stones is forbidden.
3. Pipes shall be placed from downstream, with the socket upstream. Each time work is interrupted, pipes that cannot be inspected shall be temporarily blocked to prevent foreign bodies from entering.

4. Before installation, socket and spigot ends shall be cleaned and lubricated, if necessary, with a special product.
5. Pipes joints shall be protected to prevent fill materials from entering the annular space of the flexible joints.

B. Backfilling the trench.

See section 02220 – Embankment, fill and backfill (or as shown/noted in drawings).

3.4 Tolerances

a) On laying:

4. Horizontal layout ± 5 cm
5. Vertical setting ± 2 cm

b) No intrusion of water, and especially running or spurting leaks, shall be tolerated at seals.

N.B. An intrusion of water is defined as a flow of more than 1 litre/metre of joint/day.

SECTION 04000
MASONRY WORKS

1 GENERAL

1.1 Work Included

This section covers masonry works as required for:

- Internal positions.
- Other small structures according to Drawings or specified by the Engineer.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 03300 - Concrete

1.3 Quality Assurance

Finished rendered work shall be true, plumb, or level and straight to a maximum tolerance of 3mm in a 1m.

Finished surface shall be free of waves or distortions, square with adjoining work, flush with casings, and free of any defect detrimental to appearance or performance.

All masonry works will be rendered (see 2.5) on both internal and external walls.

1.4 Codes And Standards

A. British standards

BS EN 1745	Masonry and masonry products - Methods for determining design thermal values
BS EN 772	Methods of test for masonry units
BS EN 845-2	Specification for ancillary components for masonry - Part 2: lintels
BS EN 1015	Methods of test for mortar for masonry.
BS EN 13139	Aggregates for mortar
BS EN 998-2	Specification for mortar for masonry - Part 2: masonry mortar

B. French standards

NF P 13-301	Hollow terra cota bricks.
NF P 13-304	Facing clay bricks.
XP P 13-305	Clay masonry units. Common solid or perforated clay bricks and perforated clay blocks. Requirements and test methods.

2 PRODUCT

2.1 Concrete Blocks

Unless otherwise specified, the Contractor shall provide standard hollow concrete blocks units with nominal dimensions of 400 x 200 mm. The blocks shall be 20 cm thick for outside walls and 10 cm or 15 cm for partitions. Double blocks, 10 cm thick each, could be used for outside walls, if approved by the Engineer.

No overall dimension (width, height or length) shall differ by more than 3 mm from the specified dimensions.

The minimum compressive strength shall be:

a) for individual unit: 15 MPa,

b) for the average of 3 units taken as a sample: 17 MPa.

The maximum water absorption shall be 250 kg/m³, when soaked for one hour in water.

All units shall be sound and free of cracks or other defects, and shall have uniform colour, texture and appearance.

2.2 Concrete Lintels

Lintels for doors, windows and other openings left in the concrete block walls and partitions shall be reinforced concrete designed according to the span of the opening and the wall thickness, but never less than 10 x 15 cm. Each lintel shall be reinforced with a minimum of four 10 mm dia. bars.

2.3 Mortar For Placing Blocks

General requirement for sand used in concrete (Section 03300) applies except that the sand for mortar shall contain no particle greater than 2 mm.

The mix shall be 400 kg cement per m³ of sand.

The mortar is to be mixed dry in a mechanically operated drum type mixer and water shall be added after the constituents have been thoroughly mixed.

Mortar which has begun to set or which has been mixed for more than 30 minutes shall not be used or remixed.

The mixer shall be operated at the speed recommended by the manufacturer and the total quantity of materials mixed in each batch shall not exceed the rated capacity of the mixer.

The entire content of the drum shall be discharged before a new cycle of batching is started and at all times the inside of the drum shall be kept free from a build-up of materials. The mixer drum shall be thoroughly cleaned prior to change of mix or on cessation of mixing.

2.4 Metal Wall Ties

Cavity walls and wall facing shall be provided with galvanised steel ties with a minimum section of 10 mm².

Not less than 4 ties shall be fixed per square meter.

2.5 Masonry Accessories

Unless specified otherwise, galvanized wire netting: to be 22 SWG of galvanized mesh complying with BS-1085 shall be used in interior partition walls, in addition to providing ties with ends bent to 90 degrees angle to form hooks not less than 50 mm long.

For walls higher than 3m and longer than 4m, the Contractor shall make sure to construct a 20x40cm continuous column at the end of the 4m length. All walls must be chained at the lintel level and related to the main structure. Walls shall be fixed to the ceiling with a steel profile in order to prevent falling under seismic effects.

Clip anchors shall be provided to support masonry walls to concrete structure in every other course of concrete walling and at intersection of concrete block walling.

2.6 Mixes For Rendering (Cement or Cement-Lime Plastering)

The mixes for rendering shall be:

Treatment	Mix proportions (parts by volume)		
	Cement	Lime	Sand
Exterior	1	1	5
Interior	1	1	6
Rough cast finish	1	2	9
Smooth finish	1	4	8

The method of measuring materials for the render shall be such that the specified proportions of the materials can be controlled and accurately maintained during the progress of the work.

The quantity of water shall be such as to obtain a satisfactory workability for the specific use of each render.

Render which is set or become dry or unworkable shall not be used nor retempered with water.

Any render that is not used within 30 minutes after the first water has been added shall be rejected and removed from the Site.

The equipment and tools used for transporting and for placing batched render shall ensure that contamination and loss of ingredients do not take place.

2.7 Brick Work

2.7.1 Bricks

Bricks will be used for partitions only.

Bricks shall be of the best available quality.

Bricks shall be sound, hard, uniform in colour, regular in size and shape with straight parallel surfaces and sharp arises and free of cracks, stones and lumps, especially of lime.

Bricks intended for fair-faced walls with tooled joints shall be particularly suitable with regard to durability and weather-resistance and of uniform colour.

Bricks shall be well burnt. Their compression strength shall be at least 5.5 N/mm² on an average of any twelve (12) bricks, but at least 3.5 N/mm² for any individual brick.

The Contractor shall submit brick samples along with test certificates to the Engineer for approval.

2.7.2 Damp-Proof Course

Damp-proof course shall be provided for all block-work at approximately 200 mm above ground level using.

- bituminous roofing felt not less than 3 mm thick or
- polyethylene sheeting not less than 0.5 mm thick
- or any other approved material,

laid on an even bed of cement-sand mortar (1:1) and lapped 150 mm at all joints. The damp-proof membrane shall cover the full width of the blocks.

2.7.3 Mortar

Mortar to be placed between the bricks shall be cement-lime-sand mortar in the ratio of 1:1:6.

Below the damp-proof course, the blocks shall be laid in cement-sand mortar in the ratio of 1:4.

2.8 Internal Plaster

Internal plaster shall be applied to walls and partitions in offices, toilets and entrance hall.

Internal plaster to walls and ceilings shall be applied to the bonding coat. The undercoat shall be 1 part gypsum browning plaster to 3 parts sand by volume, applied firmly in one continuous operation between angles and joints to a thickness of not less than 10 mm, cross scratched to provide a key for the next coat.

The finishing coat shall be gypsum finishing plaster applied to a thickness of 5 mm and trowelled or floated to produce a tight, matt, smooth surface with no hollows, abrupt changes of level or trowel mark. This coat shall be applied to the undercoat as soon as it has set and has developed reasonable suction. Internal plastering shall generally be carried out in accordance with BS5492.

Alternatively internal plaster to walls shall be applied to the bonding coat in two coats. The undercoat shall be a mix of 150 kg cement, 0.30 m^3 lime and 1 m^3 sand applied to a thickness of 15 mm. The finishing coat shall be to the same mix, but the sad shall be very fine, applied to a thickness of 5 mm.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

2.9 External Smooth Render

Smooth render shall be applied to plinths, columns, overflows and gargoyles, copings, and elsewhere as required.

The undercoat shall consist of one part sulphate resisting cement to two parts lime to six parts sand by volume. It shall be applied firmly in a thickness of 15 mm cross scratched to provide a key for the next coat.

The finishing coat shall be composed of one-part white Portland cement, one part lime, one part limestone powder and four parts white gypsum by volume with oxide colouring agent added to suit applied in a thickness of 8 mm. The coat shall be trowelled to create a flat, smooth, hard surface.

Coats shall be applied in a continuous operation wherever possible. Joints where unavoidable shall be formed with a neat V-joint through the full thickness of the finishing coat.

2.10 External Textured Tyrolean Render

Textured render shall be applied to mid-wall panels and roof fascias and elsewhere as required.

The undercoat shall be one part sulphate resisting Portland cement to two parts lime to four parts sand by volume applied in a thickness of 15 mm.

The textured coat shall consist of one-part white Portland cement to five parts lime to three parts of sand by volume with oxide colouring agent added to suit and shall be spattered onto the wall by a hand operated machine to five an even but rough texture to the surface. All adjoining surfaces that are not to receive the finish shall be adequately masked. The thickness of coating shall be sufficient to cover the undercoat. External rendering shall be carried out in accordance with BS 5262.

3 EXECUTION

3.1 Preparation

All surfaces designated to receive concrete blocks shall be clean and level to the lines and grades shown in the Drawings or as directed.

Laying of blocks shall not proceed until the Engineer has inspected and approved the prepared surfaces.

3.2 Blockwork (Concrete Blocks Referred All as Blocks)

Blockwork shall be built without recesses or projections unless otherwise shown on the Drawings.

Blocks shall be soaked in water before use. The tops of walls left off shall be wetted before work is recommended.

Blocks shall be well buttered with mortar before being laid and all joints shall be thoroughly flushed up, raked or pointed as the work proceeds. Except or otherwise specified vertical and horizontal joints are not to exceed 1 cm in thickness.

Blockwork shall be carried out in a uniform manner such that no portion shall be more than 1 m above another. Blockwork shall be kept true and square and the whole properly bonded together. Particular attention shall be paid to ensure strict verticality of blockwork.

Half block walls and inner and outer skins of double-skin walls and casings shall be built in stretcher bond.

All blockwork shall be cleaned down on completion to remove mortar dropping, runs or stains and again before rendering to remove any efflorescence.

Expansion joints shall be provided in external blockwork at approximately 12 m centres. The joint shall be formed with "Flexcell" or other approved expansion strip and sealed with "Sealastic" or other approved joint sealer. Care shall be taken to ensure that the wall is properly bonded or tied at each side of the expansion joint to prevent any loss of stability.

When required, galvanised steel ties, meshes or cramps shall be carefully embedded in the mortar.

3.3 Bonding of Blocks to Concrete Works

Where blockwork abuts concrete columns, walls or beams, there shall be adequate bonding between the two materials by means of wire ties or approved wire mesh which shall be recessed 40 mm from the face of the brickwork or blockwork at such intervals as approved by the Engineer.

3.4 Connection With Doors and Windows

The spaces around the door frames and built-in items shall be solidly fixed with mortar.

Spaces around the door and window hold fasts shall be filled with concrete Class A.

3.5 Bricks or Blocks to be Rendered

Blocks which are to receive rendering or plastering shall have a surface which will ensure good adhesion of the applied finish.

3.6 Rendering

Projecting burs of grout shall be removed and the surface shall be wire brushed and cleaned with scrubbers. If the surface is smooth, it shall be prepared by roughening with a pointed tool to form pocks, not less than 3 mm deep, spaced not more than cm apart.

Outside rendering shall be of uniform thickness applied in one coat of 15 mm minimum.

Inside plastering shall be 20 mm thick made of two layers: 15 mm under coat and 5 mm finished coat.

Surface shall be cleaned and wetted before plaster is applied.

Concrete work shall be rough plastered with 3 for 1 sand cement mortar which shall be kept wet for two days before base coat of plaster is applied.

3.7 Laying of Bricks

The Engineer will take samples of bricks at random from deliveries to the site for comparison with the approved specimen. Supplies which are not in conformity with the requirements shall be removed from the site.

All brick work shall be set out and built to the thickness and heights required, be built strictly vertical and all quoins etc. shall properly be bonded together, laid perfectly plumb, true to line, level and in accurately spaced courses.

Before laying the bricks, they shall be soaked in water for at least one (1) hour.

Mortar shall be mixed dry and water added until the correct consistency is obtained. All mortar shall be used within forty-five (45) minutes after the addition of water.

Walls shall be bricked up in a uniform manner so that no portion is raised more than 0.75m at any time.

Mortar joints shall be full and approximately 10 mm thick. They shall be raked out at least 10 mm deep as the work proceeds.

At concrete columns, surfaces shall be chipped and steel binders shall provide rigid connection between column and blockwork, wherever no expansion joints are provided.

3.8 Finishing

Following completion of rendering all surfaces shall be thoroughly cleaned.

Any unsatisfactory work shall be removed and the rendering shall be re-applied.

SECTION 05000
STRUCTURAL STEEL CONSTRUCTIONS

1 GENERAL

1.1 Work Included

The Work included under this Section regards the structural steel and consists of the design, fabrication, manufacture, inspection, testing, delivery to Site, unloading, where necessary storage at Site, complete erection, testing on completion, setting to work, all to the satisfaction of the Engineer.

The steelwork shall be complete in all respects, including all materials, parts, etc., so as to provide a complete and satisfactory installation. Everything necessary for the erection, operation and maintenance of the equipment shall be included, all temporary and permanent supports, foundations and anchor bolts shall be provided.

All work related to the steel structure is in the charge of this bid package even if not presented on the drawings or others documents. The price is global and the Contractor shall signal and estimate the cost of any work omitted in the tender documents or that may come from the construction methodology.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with the following sections;

- Section 01010 corrosion protection,
- Section 08200 painting,
- Section 07000 waterproofing isolation and roofing,

1.3 Standards and Codes

In case of discrepancy between different standards of the same importance, the Contractor shall refer to the Engineer.

1.3.1 Local Standards

The local standards have priority over the other standards listed below.

1.3.2 British Standard

Unless otherwise specified, steel structures shall comply with the most recent following British Standard Specifications:

BS 4	Structural steel sections.
BS 499	Welding terms and symbols.
BS 1192	Construction and drawing practice.
BS EN 1011	Welding. Recommendations for welding of metallic materials.
BS EN 1990	Eurocode 0 – Basis of structural design: All parts of Eurocode 0, including National Annexes wherever applicable
BS EN 1991	Eurocode 1 – Actions on structures: All parts of Eurocode 1, including National Annexes wherever applicable

BS EN 1993	Eurocode 3 – Design of steel structures: All parts of Eurocode 3, including National Annexes wherever applicable
BS EN 1994	Eurocode 4 – Design of composite steel and concrete structures: All parts of Eurocode 4, including National Annexes wherever applicable
BS EN 1997	Eurocode 7 – Geotechnical design: All parts of Eurocode 7, including National Annexes wherever applicable
BS EN 1998	Eurocode 8 – Design of structures for earthquake resistance: All parts of Eurocode 8, including National Annexes wherever applicable
BS EN 10021	General technical delivery conditions for steel products.
BS EN 10025	Hot rolled products of structural steels.
BS EN 10027	Designation system for steels.
BS EN 10210	Hot finished structural hollow sections of non-alloy and fine grain steels.
BS EN ISO 3452	Non-destructive testing. Penetrant testing.
BS EN ISO 4136	Destructive tests on welds in metallic materials. Transverse tensile test.
BS EN ISO 5173	Destructive tests on welds in metallic materials. Bend tests.
BS EN ISO 5178	Destructive tests on welds in metallic materials. Longitudinal tensile test on weld metal in fusion welded joints.
BS EN ISO 9015	Destructive tests on welds in metallic materials. Hardness testing.
BS EN ISO 9016	Destructive tests on welds in metallic materials. Impact tests. Test specimen location, notch orientation and examination.
BS EN ISO 9017	Destructive tests on welds in metallic materials. Fracture test.
BS EN ISO 9018	Destructive tests on welds in metallic materials. Tensile test on cruciform and lapped joints.
BS EN ISO 9606	Qualification testing of welders. Fusion welding.
BS EN ISO 9934	Non-destructive testing. Magnetic particle testing. General principles.
BS EN ISO 14343	Welding consumables. Wire electrodes, strip electrodes, wires and rods for arc welding of stainless and heat resisting steels. Classification.
BS EN ISO 17632	Welding consumables. Tubular cored electrodes for gas shielded and non-gas shielded metal arc welding of non-alloy and fine grain steels. Classification.
BS EN ISO 17637	Non-destructive testing of welds. Visual testing of fusion-welded joints.
BS EN ISO 17639	Destructive tests on welds in metallic materials. Macroscopic and microscopic examination of welds.
BS EN ISO 17640	Non-destructive testing of welds. Ultrasonic testing. Techniques, testing levels, and assessment.

Equivalent ASTM Standards.

BS EN ISO 2560	Welding consumables. Covered electrodes for manual metal arc welding of non-alloy and fine grain steels.

This list is not restrictive. All documents referenced by the standards listed above shall also be considered.

1.4 Submittals

All documents shall be transmitted in paper and digital file.

Before the start of works the contractor shall submit the construction design and calculation notice to the Engineer and Technical inspection for acceptance/approval.

The Contractor shall submit the following documents:

A. Calculation note.

B. Construction drawings.

Shop drawings of all steel structures shall show the sizes of members, method of assembly, welding, anchorage, connections and other necessary details for acceptance of the Engineer prior to fabrication.

C. Load distribution drawings.

The Contractor shall provide drawings showing the unweighted load distribution on foundations or different concrete structures for every action (permanent load, climatic loads, etc…).

D. Technical documentation.

- Characteristics of the products, construction methodology,
- Testing of materials,
- Technical documentation of the supplier,
- Certificates of conformity.

E. As-built works documentation.

2 MATERIALS

2.1 General

The materials shall be of first-class quality and shall take account of the latest technical advance in the field. Except where otherwise specified the materials shall be in accordance with the standards mentioned in the chapter 1.3 and conforming to the outcomes of chapter 1.4.

In general, all structural steel members shall be hot-dip galvanized and painted. Manufacturing of steel members shall be in accordance with EN ISO 14713. Finish of the steel members shall be done with polyester-based resin with heat hardened powder. Finish color shall be selected by the Engineer from the RAL catalogue. Finish paint thickness shall be minimum 60 to 80 µ and the adherence category class 0

The bolts, washers, nuts shall be stainless steel grade 316.

All resting sheet metal elements of steel structures shall not have a thickness inferior to 8 mm.

2.2 Steel For Metal Structures

All steel members of the structure shall be of the same steel grade.

Except where otherwise specified, the members of bolted and/or welded steel structures shall be of grade S235 JR, S235 JO, S355 J0 or S355 J2.

Steel members of grade S355 located outside and exposed to frost shall be S355 K2.

The surfaces of the steel members shall be free from any rust marks.

The limit of elasticity of hot rolled steel shall be reduced regarding the thickness of the member or metal sheet regarding BS EN 10025:

Thickness (mm) Grade	≤ 16	≤ 40	≤ 63	≤ 80	≤ 100	≤ 150
S235	235	225	215	215	215	195
S275	275	265	255	245	235	225
S355	355	345	335	325	315	295

2.3 Hot Rolled Members

Except if agreed otherwise with the Engineer, all profiles members and metal sheet shall be hot rolled steel.

All steel sheet and profiles characteristics shall comply with the BS EN 10025.

All steel hollow section members shall comply with the BS EN 10210.

2.4 Reconstituted Welded Members

All reconstituted welded members shall be constituted of steel sheet or hot rolled profiles compliant with the BS EN 10025 and weldable.

2.5 Ordinary Bolts

Ordinary bolts shall comply with BS EN 15048, shall be marked “SB” (Structural Bolt) and shall respect the following conditions:

- All ordinary bolts shall have the same grade,
- The grade of the bolts shall be the closest to the grade of the steel members to be assembled,
- The bolts shall be laminated (rolled threading),
- The bolts thread pitch shall be coarse and triangular profile,
- The minimal diameter for bolts shall be M12 (unless shown/noted in drawings),
- In case of plain rod bolt, the diameter of the plain part shall be equal to the external diameter of the threaded part.

2.6 High Strength Bolts

High strength structural bolts shall comply with BS EN 14399.

High strength structural bolts shall be delivered with complete set bolt+washers+nut and shall respect the following conditions:

- All high strength bolts shall have the same grade,
- All high strength bolts shall be of grade 8.8 or 10.9,
- The bolts shall be laminated (rolled threading),
- The bolts thread pitch shall be coarse and triangular profile,
- The minimal diameter for bolts shall be M12 (unless shown/noted in drawings).

2.7 Welding Electrode

Electrodes and every consumable product shall comply with EN 13479 and the standards mentioned in the table 5 of EN 1090-2.

The consumable products for welding shall be appropriate to the welding method, to the materials to weld and operating method.

The metal used for welding shall have at least equal mechanicals characteristics that the metal welded.

Welding of galvanised steel shall not be permitted on site.

2.8 Galvanizing

Where galvanizing has been specified the items shall after fabrication be hot dipped galvanized in accordance with BS 729, or where approved zinc coated in accordance with BS 2569 Part 1 to a thickness of 0.15 mm.

All items to be protected shall be prepared as specified in the above standards.

Articles altered as the minor alternations at site or requiring minor repair at site shall be wire brushed to remove all rust and coated with 3 coats of approved zinc rich cold galvanized compound.

The minimum weight of coating and other requirements shall be as shown in the following table. If there is a conflict between the ASTM and minimum weight columns, the minimum weight column shall apply. The weight shown is ounces per square foot of surface area. The weight of coating shall be determined in accordance with ASTM A 90, modified to determine the coating of each surface separately. All surfaces, when tested separately, shall meet the minimum requirements.

Material	ASTM	Minimum Weight of Coating (oz./sq.ft.)
Steel products including structural shapes, tie rods, handrails, manhole steps, and miscellaneous items.	A 123 A 153 B 633 B 695	2.00 2.00 2.00 2.00
Hardware including cast, rolled, pressed and forged articles.	A 153 B 633 B 695	2.00 2.00 2.00
Bolts, screws, nuts and washers	A 153 B 633 B 695	1.25 1.25 1.25
CSP culverts and underdrains	A 444	1.00
Chain link fence fabric, tie wire only	A 392	1.20
Steel pipe (includes fence posts, braces and rails)	F 1083	1.80
All other chain link fence articles	A 123	1.80
Iron or steel wire fencing	A 116	0.80
Steel or iron sheets	A 525	1.20
Barbed wire	A 121	0.80
Electrolier standards, 7 gage steel and over	A 386	2.00
Electrolier standards, under 7 gage steel	A 386	1.50

The zinc coating shall adhere tenaciously to the surface of the base material. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening, and other fabricating shall be done as far as is practicable before the galvanizing. All members, nuts, bolts, washers, etc. shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings shall be cause for rejection.

Products that are warped or distorted to the extent of impairment for the use intended shall be rejected.

Zinc coating which has been field or shop cut, burned by welding, abraded, or otherwise damaged to such extent as to expose the base metal, shall be repaired and recoated by one of the following methods:

2.8.1 Hot-Dip Process

The damaged areas shall be thoroughly stripped and cleaned and a coating of zinc shall be applied by the hot-dip process.

2.8.2 Metalizing Process

This process cannot be used unless the Contractor has the approval from the Project Manager.

The damaged area shall be thoroughly cleaned by blasting with sharp sand or steel grit. The blasted area shall lap the undamaged zinc coating at least ½ inch.

Zinc wire containing not less than 99.98 percent zinc shall be used in the metalizing operation. A zinc coating shall be applied to the damaged area with a metalizing gun

to a thickness of not less than 0.005 inch on the damaged area, and shall taper to zero thickness at the edge of the blasted undamaged section.

2.9 Sealing Products

Sealing products, where required, shall consist of epoxy cement or of aggregate, sand, cement and water in the proportions proposed by the Contractor and approved by the Engineer. Forms for contact-grouting shall be installed where necessary. Grout shall fill all space of recesses, with no voids (including the potential-voids due to lose of water and segregate of grout). After grout has hardened, any visible wedges shall be removed, and exposed joints neatly finished to a smooth dense surface.

All sealed metal pieces shall be hot-dip galvanized with a minimum thickness of 80 microns.

3 FABRICATION- DELIVERY - EXECUTION

3.1 General

Each part shall be clearly marked in such a manner that part can be easily identified on shop erection drawings.

Members shall not be overstressed during the transportation and construction.

Hammering shall not be permitted.

Any steel piece damaged during transport or erection shall be removed by the Contractor and replaced by new materials to the satisfaction of the Engineer at no extra cost to the Employer.

Assemblies realized in factory shall only be welded. For important structural pieces the Contractor shall submit to the Engineer a drawing showing the implementation of welds, before their execution. This drawing shall be realized to limit the stress due to thermal deformation.

Assemblies realized on site shall only be bolted. Every welded assembly on site is banned.

Hollow sections subject to water retention shall be holed to permit water evacuation.

3.2 Delivery and Storage on Site

All metal parts shall be cut, holed and curved at the factory as per the construction drawings and shall be delivered at site prepared to be jointed or erected. They shall be delivered with at least the first layer of corrosion protection.

All frames shall be provided with suitable bracing to maintain alignment during transport.

All the metal parts shall be stored on timbers above a concrete or gravel area but shall not be in contact with the soil. The storage shall be weather-protected, disposals shall be taken in order to avoid projections and degradations. Any potential degradation shall be repaired, with a method accepted by the Engineer, or replaced at the expense of the Contractor.

3.3 Erection

The contractor shall verify implantations, levelling and squareness of structures before erection.

Before any work on erection is begun on the Site, the Contractor shall submit to the Engineer the methods he proposes to use for the erection of the steel and shall make any arrangements and take any precautions directed by the Engineer. Notwithstanding these requirements the entire responsibility for the adequacy of the Temporary Works shall rest with the Contractor.

The Contractor shall be responsible for the accuracy of setting out of all steel structures. He may use shop details and other necessary drawings prepared by the supplier. The acceptance of the Engineer for any such drawings shall not relieve the Contractor of responsibility for the correct fitting of all material.

3.4 Cutting

Shearing or cropping shall only be allowed for cutting of strips and plates less than 12mm thick.

Hand flame cutting will not be permitted.

Burrs and irregularities from cutting shall be removed.

The hardness (HV10) of edge strips shall not be superior to 380 for S235 to S460 steel. If necessary, in order to acquire the required hardness of edge strips, a pre-warming of materials can be exercised.

The notches shall be straight-lined and respect the required spacing for connections.

3.5 Welding

Welding shall be metal-arc welding complying with the requirements of BS EN 1011, EN ISO 3834 and BS EN 1993. All welds shall be continuous unless specified otherwise. All fillet welds shall approximate to the thickness of the thinnest member to the joint. Members to be joined by welding shall be cut accurately to size, with edges sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from rust, grease, cracks or any foreign matter along the edges prepared for welding. The cut surfaces shall be free of all injurious defects. All parts shall have the edges accurately prepared to the appropriate profile for welding.

No welding of galvanized steel shall be permitted on site.

All weld length shall not be less than 3mm.

Welding without pre-warming shall not be realized on steel part of thickness superior to 30 mm.

Welding shall be carried out only under the direction of an experienced and competent supervisor and only certified welders qualified in this class of work in accordance with BS EN ISO 9606 shall be employed. Welding procedures shall be such that residual stresses are minimal and that distortion is avoided.

The inspection of welds is the responsibility of the Contractor. Inspection of welds in all steel may begin immediately after the welds are completed. All fillet welding shall be visually inspected and every imperfection shall be tested by ultrasonic, crack detection, or other approved means. For all items of steelwork, the Contractor shall allow for the cost of adequate radiograph examination of the welds. The welds and positions to be examined shall be accepted by the Engineer before operation. The welds shall be accepted or rejected regarding the criterions defined in the standards.

The Contractor shall secure the services of an approved organization qualified in the inspection of welds and will bear the cost of this inspection service.

Inspection of all welds shall be done only by persons skilled in such inspection and who are acceptable to the Supervisor. The Supervisor shall review and interpret radiographs and other non-destructive or destructive testing and has the sole authority to accept or reject the inspection or Works.

All film and/or other records of weld inspection shall become the property of the Contracting Authority.

In the inspection of welds, the presence of any of the following defects in excess of the specified limits will result in rejection of the weld as being detective:

1. Cracks. Cracks, regardless of length or location, will not be allowed.
2. Overlaps. Overlaps, lack of penetration or incomplete fusion will not be allowed.
3. Inclusions, Including slag, Porosity and Other Deleterious Materials. Inclusions less than one and one-half (1.5) millimeters in the greatest dimension will be allowed if well-dispersed, such that the sum of the greatest dimensions of the inclusions in any twenty-five (25) millimeters of welded joint does not exceed nine and one-half (9.5) millimeters and there is no inclusion within twenty-five (25) millimeters of edge of a joint or a point of restraint.
4. Inclusions, Including Slag, Porosity and Other Deleterious Material. Inclusions one and one-half (1.5) millimeters or larger in greatest dimension will be allowed provided that such defects do not exceed the following limits:
    a) Six and one-half (6.0) millimeters, for T up to nineteen (19) millimeters, one-third (1/3) T, for T from nineteen (19) millimeters to fifty-seven (57) millimeters, nineteen (19) millimeters, for T over fifty-seven (57) millimeters, where T is the thickness of the thinner plate being welded.
    b) Any group of inclusions in line that have an aggregate length greater than T in a length of twelve (12) T will not be allowed.

Defects shall be removed by mechanical means or by oxygen grooving, after which the joints shall be welded again.

3.6 Bolting

All bolted assemblies shall be realized using ordinary bolts or high strength bolts and comply with the BS EN 1993 and EN 1090.

Between all nuts and steelwork at least one normal washer must be used for ordinary bolts. Washers shall be placed both under the nut and the bolt head for high strength bolts.

Embedding assemblies as well as alternated stressed assemblies shall not be realised with ordinary bolts.

All nuts and bolts shall be securely fastened to prevent loosening due to vibration.

Stainless steel bolts, nuts and washers shall be used for holding all renewable parts and all parts made of stainless steel.

The Contractor shall have a torque wrench at Site for tightening and checking of bolts at all times.

3.7 Bending

No straightening or flattening by bending or use of heat shall be carried out without acceptance of the Engineer and, if so, accepted such straightening or flattening shall be carried out as specified by the Engineer.

3.8 Holing

All holing shall be carried out at the factory before delivery on site by drilling, punching, laser cutting or plasma jet unless accepted otherwise by the Engineer.

Holes may be punched provided that the piece thickness is inferior to the diameter of the hole. Holes shall be punched with a diameter inferior to 2mm from the final diameter. Punching without reaming is not permitted.

All holes for bolts shall be free from burrs. The maximal diameter of the holes shall be equal to the nominal bolt size plus (unless noted in drawings):

- 1 mm for bolts diameters 12mm and 14mm,
- 2 mm for bolts diameters 16 to 24mm,
- 3 mm for bolts diameters 27 and more.

The clearance angle shall not be superior to 4.

Holes realized at wrong positions shall be filled by welding and redrilled at the appropriate position.

3.9 Corrosion Protection

Corrosion protection, galvanization (in case of treatment plant) and/or painting shall be carried out in accordance with Section 01010 - Corrosion protection.

The surfaces inaccessible in the joint areas shall be treated before assembly.

3.10 Fire Protection

Steel structures shall be protected from fire by spray protection, intumescent coating or other accepted means.

3.11 Electrical Continuity

All metal parts of the structure shall be connected to each other and to the ground.to dissipate any electrical load. At each column foot, the contractor shall weld a metal plate to ensure the connection with the ground.

3.12 Tolerances

A. General

All tolerances shall allow proper operation of the equipment and comply with the requirements of BS EN 1993 and EN 1090-2.

B. Fabrication tolerances

The positive or negative tolerance on every linear dimension L (in meter) is equal to: +/-(L/500+2) mm (millimeter).

C. Erection tolerances

- Column inclination for a single floor structure: h/300,
- Average column inclination for a single floor portal frame: h/500,
- Bridge crane column inclination for a single floor structure: h/1000,
- Column inclination for a n floor structure: Sh / (300√n),
- Column inclination in a floor of a multi-storey structure: h/500.

D. Implantation tolerances

For steel construction structures, deviation between the realized vertical axis of an element and its theoretical axis of implantation is limited to 5mm.

E. Leveling tolerances

Deviation between the realized level of a supporting element (column, beam…etc.) and its theoretical level is limited to +5mm.

3.13 Monitoring And Tests

A. Self-monitoring

The contractor shall carefully realise its procedure of self-monitoring.

Such control includes but is not limited to:

- Control of materials,
- Control of the storage of materials,
- Control of the interface between interfaces with other actors of the project,
- Control of fabrication and erection,
- Control of testing.

This procedure of quality assurance shall be reported to the Engineer. Self-monitoring sheets shall be provided, at least on the following aspects:

- Approbation of documents,
- Implantations,
- Geometrical characteristics (verticality, flatness, tolerances),
- Nature of the products and their testing,
- Thickness of corrosion protection,
- Thickness of fire protection.

B. Testing of the structure

Testing on the new structure shall be realized at the demand of the Engineer.

Except if otherwise specified the tests will be at the charge of:

- The Employer if the tests are positive,
- The Contractor if the tests are negative.

SECTION 05100
STEELWORKS

1 GENERAL

1.1 Work Included

The Work included under this Section consists of shop design, supply and installations of miscellaneous metalwork (steel, stainless steel, aluminium…) when required, including but not limited to the following items (if any):

1. Railings.
2. Ladders.
3. Steel stairs and rungs.
4. Hatches.
5. Hand rails.
6. Footbridges.
7. Chain-link fences.
8. Cast iron frames, covers and gratings.
9. Steel frames for precast concrete covers, miscellaneous metal covers and gratings.
10. Placing of anchor or embedded items.
11. Various steel supplies.

The work shall include all fittings, cutting, drilling and blocking required to install the Work, and to make all the required connections with adjoining work. All anchors, sockets, pipe sleeves and expansion bolts required for fixing the metalwork to the construction shall be furnished by the Contractor, except anchors for erection of equipment supplied under other contracts which will be supplied by other Contractors.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 01010 – Corrosion protection;

C. Section 03300 Concrete

1.3 Quality Assurance

a) General

Manufacturing of metalwork shall be executed by qualified personnel.

b) Qualification of Welders

Welders shall be certified welders in accordance with AWS 01.1.

Uncertified welders shall pass at site qualification tests in accordance with procedures recommended by AWS 01.1.

c) All the aluminium installation should be manufactured by a single manufacturer with a uniform finish and based on a prototype approved by the Engineer.

1.4 Standards and Codes

1. Eurocodes
2. American Society for Testing and Materials
   a) ASTM A 36 .....Specification for Structural Steel
   b) ASTM A 48 ..... Specification for Gray Iron Castings
   c) ASTM A 53 ..... Specification for Pipe, Steel, Black and Hot-Dipped,
   d) Zinc-Coated Welded and Seamless
   e) ASTM A 307 .....Specification for Carbon Steel Bolt and Studs, 60 000 psi Tensile
   f) ASTM A 575 ..... Specification for Steel Bars, Carbon, Merchant Quality, M-Grades
   g) ASTM A 788 .....Specification for Steel Forging, General, Requirement.
   h) ASTM B 221..... Specification for aluminium Alloy Extended bars,
   i) Rods, Wires Shapes and Tubes
3. American Welding Society

AWS D1.1 Structural Welding Code

1.5 Shop Drawings

The Contractor shall prepare all shop drawings and possible erection drawings on the basis of the data contained on the Construction Drawings, the design criteria supplied by the Engineer and the actual dimensions of the structures and items already built.

Shop drawings of all metalwork shall show detail of assembly, method of assembly, detail of anchorage or connection with the main structures.

1.6 Submittals

The Contractor shall submit the following documents:

- Copies of certified manufacturer's tests.
- Shop drawings and erection drawings shall be submitted to the Engineer's approval at least one month before beginning the manufacture of the various items.

1.7 Tolerances

A. Manufacture Tolerances
   1. Dimensions without direct influence on the assembly of the element: 0.2%.
   2. Main dimensions: 0.1%.
   3. Local (area 200 x 200 mm): 0.5/400 cm².
   4. Flatness: 1 mm.
   5. Main parallelism, main squaring: 1 mm/m.
   6. Straightness, alignment: 2 mm.

B. Erection Tolerance
   1. Dimension without influence on the operation of the element: 0.2%.

2. Main dimensions: 0.1%.
3. Local (area 200 x 200 mm): 0.5/400 cm².
4. Flatness: 1 mm.
5. Straightness, alignment: 2 mm.
6. Verticality: 2 mm.
7. Horizontality: 2 mm.

C. All tolerances shall allow proper operation of the equipment.

2 PRODUCTS

2.1 Materials

Except where otherwise specified, in accordance with EN 1993, EN 10025, EN 10210 and 10219.

2.2 Fabrication

Each part shall be clearly marked in such a manner that part can be easily identified on shop erection drawings.

All metalwork shall be carefully and accurately assembled by welding or by screws, bolts and rivets, concealed as far as possible.

The joints shall be filled, milled or machined as may be necessary to secure close and perfect connections. All frames shall be provided with suitable bracing connections. All frames shall be provided with suitable bracing to maintain alignment during transport.

Members shall not be overstressed during the construction and hammering will not be permitted.

Any metalwork damaged during transport or erection shall be removed by the Contractor and replaced by new materials to the satisfaction of the Engineer at no extra cost to the Employer.

Built-up work shall be assembled completely at the shop, accurately finished and the section match-marked for field erection.

Concerning ladders, the fabrication shall include back protection whenever the ladder height is more than 2 m.

3 EXECUTION

3.1 Inspection

The Engineer will inspect all metalwork before erection on Site, such inspection covering:

1. assembly quality,
2. geometric characteristics,
3. corrosion protection,
4. embedded supports,
5. quality of surface finish.

3.2 Erection

No metalwork shall be incorporated into the Permanent Works until it has been inspected and approved.

All embedded metalwork shall accurately set in place before the concrete is poured or, subject to the approval of the Engineer, recesses may be left in the concrete and the metalwork placed, anchored and blocked in place after the concrete of the structures has set.

Where, in the Engineer's opinion, it is impracticable during construction to place anchors or fasteners required for the installation of ladders, or other miscellaneous metalwork, holes shall be drilled in the structures and expansion bolts installed.

Grout, where required, shall consist of epoxy cement or of aggregate, sand, cement and water in the proportions proposed by the Contractor and approved by the Engineer. Forms for grouting shall be installed where necessary. Grout shall fill all space of recesses, with no voids. After grout has hardened, any visible wedges shall be removed, and exposed joints neatly finished to a smooth dense surface.

3.3 Welding

Members to be joined by welding shall be cut accurately to size, with edges sheared, flame-cut, or machined to suit the required type of welding and to allow thorough penetration. The surfaces of plates to be welded shall be free from rust, grease, and other foreign matter along the edges prepared for welding. The cut surfaces shall be free of all injurious defects.

Weddings shall be made in accordance with the Code for Arc and Gas Welding in Building Construction, as formulated by AWS. All welding shall be continuous along the entire line of contact, except where tack welding is permitted. All exposed welds shall be ground smooth.

No welding of galvanised steel shall be permitted on site.

Inspection of welds in all steel may begin immediately after the welds are completed. In addition to inspection as required by AWS D1.1, all welds shall be visually examined. Procedure, technique and standards of acceptance shall be in accordance with AWS D1.1.

The Engineer reserves the right to direct radiographs of the welds. Location and findings of all radiographic inspections, together with descriptions of any repairs made, shall be recorded on proper testing sheets.

3.4 Corrosion Protection

Corrosion protection, galvanization and/or painting shall be carried out in accordance with Section 01010 - Corrosion protection.

SECTION 06400
WOOD WORKS

1 GENERAL

1.1 Work Included

This section covers rough and fine timber for structural elements, frames and finishing where required in the buildings.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 03300 - Concrete

C. Section 08100 - Aluminium doors and windows, glazing.

1.3 Standards and Codes

D.T.U. No. 36.1

BS 1186	Quality of timber and workmanship
BS 1455	Plywood manufactured from tropical hardwoods
BS 3444	Blackboard and lamina board
BS 4787	Internal and external wood doorsets door.
BS 5450	Specification for sizes of hardwood and methods of measurement
BS 5669	Part 1 Methods of sampling conditioning and test.
BS 5669	Part 2 Specification for wood clipboard.
BS 6566	Plywood manufactured from tropical hardwoods
ASTM A-307	Specification for Carbon Steel Bolts and Studs, 60 000 psi Tensile
ASTM D-3110	Specification for Adhesives Used in Non-structural Glued Lumber Products
ASTM D-3499	Test Methods for Toughness of Plywood
ASTM E-283	Test Method for Rate of Air Leakage Through Exterior Windows, Curtain Walls and Doors
EN 1995	Eurocode 5: design of timber structures

1.4 Guarantee

If any shrinkage or warping occurs or any other defect appears in the joiner's work, before the end of the Defects Liability Period, such defective work shall be taken down and replaced and any other work disturbed shall be made good at the Contractor's expense.

1.5 Hardware, Locks and Glazing

Locks and Glazing shall be in accordance with Related Section 08100.

1.6 Description

Doors and door frames located in halls and offices shall be made of wood.

Wooden timbers will not be accepted for the purpose of this project.

1.7 Submittals

Unless specified otherwise, the Contractor shall:

- Product Data: Submit manufacturer's specifications, installation instructions and certification stating that the fabricated work meets the woodwork grade selected.
- Shop Drawings: Submit shop drawings showing location of each item, dimensioned plans and elevations, large scale details, attachment devices and other components.
- Wood Treatment Data: Submit chemical treatment manufacturer's instructions for proper use of each type of treated material.
- Samples: Submit the following samples for each species and cut or pattern of architectural woodwork.
- Prefinished solid work.
- Prefinished plywood.
- Samples of miscellaneous accessories required for any item specified for review and selection by the Engineer.

2 PRODUCTS

2.1 Timber

2.1.1 General Requirements

1. Materials shall comply with the European standards applicable to the type of wood: EN 14081, EN 14080, EN 14374, EN 14279, EN 636, EN 300, EN 312 and EN 622
2. The Drawings show general arrangements or outlines, indicating completely assembled work, and structural requirements where relevant. The Contractor shall produce designs and offer standard locally-manufactured items and details for approval.

   These will be considered by the Engineer and minor dimensional changes to the structure made as necessary to accommodate standard items wherever possible. Where standard items cannot be used, the Contractor shall produce at his expense such further drawings and sketches as are necessary to define joinery details and otherwise supplement the Engineer's general or outline arrangements shown in the Drawings. These shall be agreed with the Engineer before work starts on the items concerned.

   At an appropriate early stage in the Contract, the Contractor shall submit for approval samples of timber, related materials and, where appropriate, finished work for items such as doors, door frames and window frames. The name, origin and grading of each proposed timber shall be stated, together with details proposals for preservative treatment. Once samples have been approved they will be retained by the Engineer as a standard and any work failing to meet the standard of the relevant sample will be liable to rejection.
3. Timber shall be first class from the heart of a sound tree, in which the sap wood is entirely removed, and the wood is uniform in substance, straight in fibre, free from large or dead knots, flaws, shakes or blemished or any kind.

4. For first class teak wood, the size of the knot shall not be more than 13 mm and there should not be more than one knot in every 0.25 m³ of timber.
5. For first class deodar wood, the size of the knot shall not be more than 25 mm and there shall not be more than one knot in every 0.12 m³ of timber.

2.1.2 Seasoning of Timber

Moisture contents for timber less than 2.5 cm thick shall be not more than 12% and shall be less than 15% for timber more than 2.5 cm thick.

2.1.3 Storage

Timber shall be stored in a dry ventilated covered storage.

Care shall be taken to prevent damage to the timber.

Joinery shall be protected from the weather during transit and shall be stored under cases, clear of the ground in clear, dry, ventilated structures after priming.

2.2 Formica

Formica shall have 1.5 mm thickness with 0.5 mm lamination and matte finish.

2.3 Glue and Adhesive

Adhesive shall comply with ASTM D-3110.

Laminated woods shall be glued using water resistant adhesive having minimum shear resistance of 1.4 MPa at 35□C, and of 0.1 MPa at 116□C.

For teak wood sheet and other mill works "Herferinu" adhesive or approved equal shall be used.

2.4 Nails, Screws and Bolts

Nails, screws and bolts shall be galvanised.

All nails and screws used with reactive timber (becoming stained and disfigured by reaction with ferrous metals) shall be non-ferrous metals.

The diameter of the nail or screw shall be suited to the woods being fixed and to which a fixing is being made, and the length shall be such as to give a sufficiently strong and secure fixing.

2.5 Wooden Skirting

Wooden skirting shall be made of deodar.

3 CONSTRUCTION

3.1 Shop Assembly

All woodwork, as far as practicable, shall be assembled in workshop, finished and prime coated before delivery for fixing.

3.2 Installation

The installation shall be executed with accuracy and perpendicular plumb shall be respected.

The Contractor shall verify on site, the exact dimensions of the openings and shall take all precautions in order that the carpentry do not get deformed during setting and before the plaster dries.

The maximum play tolerated between mobile parts or between permanent and mobile parts shall be 1mm.

When closed, the doors shall be absolutely tight and the split hinges shall be vertical.

Door frames shall be fixed to walls or to concrete, each by means of seven sealing flaps and anchored well and deep enough as compared to the plastering. The length of the groove in the frame intended for fixing the sealing flap, shall not exceed the width of joint-cover.

All the used iron parts and notably the sealing flaps shall be coated with, at least, two layers of paint before using them. Each of them shall be long and shall have a section of 25mm.

The tip of the case side shall be fixed to the case by screws and not nails. The other tip shall be split.

Sealing shall be made with cement mortar well stuffed in the pending holes. The backside of the frames and all door or window frames in contact with the concrete or the masonry shall be coated with creosote, xylophone or any other similar protective product, before fixing.

All carpentry and wooden pieces shall receive a priming layer before the installation.

It is forbidden to use wedges or mastic to conceal the defects of the wood, or of the defective assembling. Mastic shall only be tolerated in order to cover a metal part embedded in the wood (nails, hinges).

3.3 Joints

All joints shall be mortise and tenon joints, unless otherwise specified or shown on the Drawings. The joints shall fit truly and fully without filling.

All joints shall be fixed with tight driven hard dried wooden or bamboo plugs. Joints shall be secured with approved glue before the framing is done.

Glue shall not be used in joints which are exposed.

3.4 Nails and Screw

The holes of correct size shall be drilled before inserting screws. Hammer shall not be used for driving in or starting in the screw. All screws shall be dipped in oil before they are inserted in the woods.

The heads of the nails or screws shall be sunk and puttied.

3.5 Door Frames

Frame thickness shall be as shown on the Drawings.

Doors shall have 1.7 mm (± 0.5 mm) clearance from their frame at each side.

The leaf of each door shall be fixed to the frame with 3 hinges.

3.6 Door Leaves

Flush doors shall conform to the applicable requirement of ASTM-E 283.

Door leaves shall be of well-seasoned hardwood, cross gained and face veneered with 5 ply 6 mm plywood on each side as shown on the Drawings.

Doors shall operate under a force of less than 5 daN.

3.7 Tolerance

All doors shall conform to the requirement of EN 24.

3.8 Finishing

Any exposed surface of timber works shall be smooth, even, and neat.

In addition to sanding machine, all woodwork shall be smoothed by hand using "OO" sand paper to achieve the required smooth surface, free from machine and tool marks, abrasions, raised grains and other undesirable defects.

Oil borne or water borne preservatives shall be applied to timber surfaces to be painted or to be connected to any painted surface. Coal tar creosote or any creosote solution shall not be used.

Unexposed Timber works shall be painted before installation.

3.9 Precautions

3.9.1 Protection

All precautions should be taken by the Contractor to preserve and protect the timber or wooden items erected at site against weather, insects, injuries, etc., during the whole construction period.

3.9.2 Preservation

Preservation material shall be applied in strict accordance with recommendations of the preservative manufacturer and shall be given to all woodwork which comes in contact with or built into any wall, floor, ceiling or any other structure. All the rough woodwork which is not finished and exposed woodwork whether abutting any structure or not shall be given preservative treatment.

3.10 Covering the Timber

The Contractor shall give at least 7 days' notice to the Engineer in writing where any timber is to be covered in the ground or in walls or otherwise. Failing this, the Engineer may order it to be uncovered at the Contractor's expense.

No paint or varnish shall be applied unless the finishing is approved or otherwise the work shall be liable to be rejected in whole or part.

3.11 Hardware

All hardware and various equipment shall be in accordance with the last issue of NFP 26-303.

Samples of the various equipment shall be presented to the Engineer as soon as possible for the selection of the models that are to be used.

The Contractor shall supply all locks, split hinges, braces, handles, bolts, various door stops, automatic door pushers, stops, pegs, etc. unless otherwise specified by the Engineer.

All locks shall be of the best marks, safety locks with a mortise and a cylinder.

1. All internal one leaf doors shall comprise:
    - One safety lock with a mortise and a cylinder mechanism.
    - Three split hinges with 140mm blades, square ends, and a brass ring.
    - A pair of handles.
    - Two plates.
    - A door-stop.

Accessories shall be made of dull chromium-plated brass and shall comprise all necessary rings and washers for the installation and mounting of the hinges, leaving no play, and shall be approved by the Engineer.

Two-leaves doors shall comprise, in addition, three split hinges for the second leaf, two bolts, covers for fixing holes to be fixed on the tiling or in the wood.

SECTION 07000
WATERPROOFING, INSULATION AND ROOFING

1 GENERAL

1.1 Work Included

The works covered by this Section relate to the following items:

- Roofing;
- Framework;
- Covering;
- Weather-proofing;
- Heat insulation;
- Sound insulation
- Odour-proofing.

of all the closed and covered enclosures in order to guarantee closure and cover, and to prevent nuisance caused by noise and smells.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

- Section VII – A. General requirements;
- Section 01010 – Corrosion protection;
- Section 05100 - Steelworks.

1.3 Description

The works in the present Section will cover all necessary works for the completion of the building, including framing, insulation, claddings, cladding accessories like bottom flap, acroterion cover, corner pieces, opening surround, cover strips, plugging, ...

All the holes in the cladding will be such as to avoid any deformation (oblong holes), in any direction due to the deformation of the framing.

All the supply for the present Section shall be manufactured by a single manufacturer to insure a uniform finish.

When required, special washers shall be introduced to avoid direct contact between framing and aluminium cladding.

It also includes supply and installation of:

- Stormwater downpipes;
- Zenith lighting;
- Smoke outlets and associated remote control devices;
- Connections for roof outlets for smoke pipes or ventilation ducts;
- Connection and interface works between the different structures;

- All the accessories needed for perfect finishing work;
- Protective barriers to prevent falling of personnel and objects during the works period in accordance with regulations in force on the date of signature of the contract.

1.4 Codes and Standards

Works are to be carried out in accordance with standard professional practice, and in compliance with all current rules and standards.

- For example, French Standards AFNOR may be used together with DTU Specifications (Series 43 - Waterproofing, 43.1, 43.2, 43.3 and 43.5 - Ribbed steel sheet roofing.)
- Specific trade regulations where relevant (claddings, double-sided roofing, etc.).
- Fire prevention regulations (APSAIRD rules).
- Industrial safety regulations.

The Contractor shall propose a product and the corresponding standards guaranteed by the supplier and/or the manufacturer.

1.5 Submittals

- Calculation notes for framework, roofing, insulation, etc.
- Working design drawings with associated justification and detailed technical specifications;
- Report of terrace water priming test;
- Technical solutions, processes and schedule for work on structures to be rehabilitated.
- Colour shall be approved by the Employer and for this purpose, samples shall be submitted to the Engineer together with documentation required.

2 PRODUCTS

2.1 General

The materials used must comply with standards and regulations in force at the time of signature of the contract and must take into account the aggressive ambient atmosphere.

2.2 Translucent Panels

If PRV colourless translucent ribbed panels are used for external roof cladding, they shall comply with Standard NF P 38301 and shall be installed as indicated on the Drawings.

The supply shall include any additional connecting and supporting accessories.

2.3 Heat Insulation

2.3.1 Vapour Barrier

Self-adhesive strips or added screens shall be laid as per DTU.

2.3.2 Insulating Sheets or Panels

Non-loadbearing insulating panels shall be installed and will contribute to heat resistance. It shall be laid as recommended per DTU.

Work shall comprise all laying and connection constraints, in particular for ventilation between roof sheets and insulation.

If panels are used, they shall be cut and raised level with ridge ventilation openings, to ensure free ventilation of buildings.

2.4 Roof Claddings

A. Cladding shall be constructed of prelacquered steel sheets with minima thickness of 0.50 mm.

B. All accessories shall be prelacquered aluminium, as for outside cladding, with the same colour, or another colour as approved by the Engineer.

   All types of additional profiles and joint needed (like compriband expandable joints or gun laid joints), particularly at connecting points with other structures (for instance masonry, window and door frames) shall ensure absolute air and watertightness and perfect finish.

C. Bottom flap shall be provided to form a dripboard at connection with walls and openings, closing up the bottom of the roof panels.

D. Acroterion cover shall be provided and crowns the top, at the connection with gutters, flashings or counterwallings.

E. Corner pieces shall be provided and especially shaped for re-entrant and projecting angles.

2.5 Roof Waterproofing

Polyurethane waterproofing materials shall be applied on roofs where required.

The materials to be applied shall have the following characteristics:

- A deep penetrating polyurethane (pre-polymer) primer having the below characteristics:
  - Density : 1.1
  - Adhesion to concrete : > 1.8N/mm2
  - Resistance to water pressure : No leak at 7 bars
  - Consumption : about 200g/m^2 for concrete.
- A waterproofing polyurethane membrane, highly permanent elastic, having excellent thermal resistance and having the following characteristics:
  - Density 14Kg/Lt
  - Elongation at break : >600%
  - Tensile strength : >4 N/mm2
  - Crack bridging capability : up to 2mm crack
  - Service temperature : -30°C to 90°C
  - Consumption : 2kg/m2, applied in 3 layers
- For uncovered/unprotected waterproofing membranes, an aliphatic polyurethane top-coat shall be applied, UV -stable, allowing domestic pedestrian access, highly elastic, resistant to water, heat and frost, having the following characteristics:
  - Resistance to water pressure : No leak (DIN EN 1928)
  - Elongation at break : > 285% (EN ISO 527)
  - Tensile strength : >3.70 N/mm2 (EN ISO 527)
  - Chalking grade : 0
  - UV accelerated ageing : No significant changes (EOTA TR – 010)
  - Service temperature : -40°C to +90°C

- Consumption : 250 gr/m^2, in two layers.
- UV protection : According to ASTM C957/C957M.

The corners angles shall be smoothened using no shrink mortar.

The connection between concrete and steel materials shall be treated with appropriate waterproof sealant material.

2.6 Flexible Waterproofing PVC Sheets 2 mm Thick

2.6.1 Description

This work shall consist of furnishing and placing flexible PVC sheets 2 mm thick on prepared surfaces in accordance with the Specifications, and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the Supervisor.

2.6.2 Materials

Waterproof membranes shall consist of uniform flexible sheets of two (2) mm minimum thickness.

The waterproofing PVC sheets shall comply with the following specifications at 20 °C:

- Weight 2.80 kg/m^2
- Thickness 2 mm
- Tensile strength at rupture 17 daN/cm
- Elongation % 170 %
- Bursting Test (C.T.G.R.E.F.) > 12 Bars
- Hydrocarbon resistance Good
- Chemical resistance Very good

The Contractor shall provide all adhesives, tapes and welding material recommended by waterproofing sheets manufacturer for bonding to substrate (if required), and for waterproof sealing of joints between membrane and flashing, adjoining surfaces and projections through membrane. The Contractor shall also provide all types of flexible sheet material and accessories for flashing and welding as recommended by waterproofing sheet manufacturer.

Each side of the waterproof membrane shall be protected by one layer of heavy-duty geotextile sheets, in accordance with the Contract Drawings and Specifications.

2.6.3 Construction Requirement

- Manufacturer's Instructions and Recommendations

At least thirty (30) days prior to the date he intends to order the waterproofing sheet materials the Contractor shall make written request for approval of: the brand of materials and method of installation he intends to apply, from the Project Manager.

The written request shall include all necessary manufacturer's instructions and recommendations relevant to the physical properties of the proposed sheets, the methods of storage, handling, laying, jointing, attachment, and protection. No ordering of waterproofing sheet material shall be effected before obtaining the written approval of the Project Manager on the above.

- Subgrade Preparation

Unless other subgrade preparation is called for on the plans or appears as a pay item in the Bill of Quantities, the Contractor shall, as a part of the work and prior to the delivery of the material for the waterproof membrane, prepare the bed surface by sprinkling, blading, rolling, and lightly scarifying

where necessary, until the proper slope is obtained. However, in the process of shaping the bed, the originally compacted crust or top portion of the bed shall be disturbed as little as possible. When completed and ready for waterproof membrane construction, the bed shall be well compacted, smooth, hard and uniform, all irregularities having been bladed out and rolled down.

- Placing

The waterproof sheets shall be unrolled directly on the bearing surface, generally constituted by a layer of heavy-duty geotextile sheets. Waterproof sheets shall be overlapped to a minimum of twenty centimeters, and shall be welded on site by means of a thermoplastic soldering machine to seal the membranes and ensure water tightness to these joints, all in accordance with Manufacturer's instructions and recommendations. The strength of the welding shall be at least equal to that of the sheets.

Installation shall be scheduled to minimize period of exposure of sheet waterproofing materials.

Equipment and vehicles shall not be operated on the fabric. Damaged fabric shall be repaired, at the Contractor's expense, by placing new fabric over the damaged area in a manner that meets the overlap requirements for horizontal placement. Vertically placed fabric shall be replaced in its entirety.

2.7 Geotextile Sheets

Geotextile sheets shall be of the non-woven heavy-duty type, needle punched or needle entangled and shall consist of long chain polymeric filaments of polypropylene, polyester, nylon or any material approved by the Supervisor. The fabric shall be a stable network of fibres, which retain their positions relative to each other. The geotextile sheets shall meet the following requirements:

Property		**Test reference**
Grab strength	: 500N	NFG 38.014
Elongation, Min (at peak load) %	: 65/57	NFG 38.014
Puncture strength	: 1500N	NFG 38.019
Permeability m/sec	: 5.5x10-3	NFG 38.016
Surface weight	: 390 Gr/m^2	NF EN 965
Thickness under 2kPa	: 2.0 mm	NF EN 964-1

Geotextiles shall be furnished in rolls wrapped with protective covering to protect them against ultraviolet radiation and abrasion. Torn wrappers shall be repaired within 48 hours, using an approved protective covering. Each roll of fabric shall be marked or tagged to identify the manufacturer, type, length, width, and production identification number.

2.8 Bituminous Putty

2.8.1 Putty Filler

Putty filler must have a consistent, semi-rigid and compatible with flexibility inside the joint. Before fillings the joints must be dry and clean and the concrete surfaces in contact with putty must be primed with compatible material with the putty.

Putty must be of type "IGAS" or similar with bituminous base or rubber having the following characteristics:

- Density : 15
- Flexibility at 20° : null
- Adhesivity of cohesiveness : 3 daN

- Maximum elongation under service : 10%

Excellent adhesivity when laid on cement.

Another type could be used which is the elasto-plastic type conforming to the following requirements:

- Black colour
- Temperature for use : 100°C to 130°C
- Stable at : -30°C to 60°C
- Penetration at 25°C : around 55°C
- Softening temperature : around 145°C
- Practical elongation : 10%
- Non-toxic

The selection of which type to be used shall be approved by the Supervisor.

2.8.2 Application of the Sealant

Before proceeding with filling the joint, the Contractor shall complete the following works:

- Widening the joint by grinding or sawing when the joint width is less than required.
- Cleaning by grinding and brushing the sides of the joint all along its length.
- Final cleaning shall be done by blowing air immediately before starting the filling.

The putty is applied at a temperature ranging between 100°C and 130°C. It shall be filled in the joint from the bottom up. In case the putty spreads slowly when applied, especially in horizontal joints, more material is immediately added until the joint is completely filled.

2.9 Waterstops

2.9.1 General

Note: Locations of the waterstop joints shall be shown on shop drawings to be submitted by the Contactor for the Engineer approval.

Waterstops shall be PVC type or Vulcanized Caoutchouc class A (rubber water stop) and shall be installed where shown on the drawings or where directed.

The Contractor shall furnish the waterstops and all materials and equipment for splicing waterstops, for fastening waterstops to the forms and to the supporting reinforcing bars, and for completing the installation of the waterstops.

The Contractor shall provide suitable support and protection for the waterstops during the progress of the work and shall repair at the Contractor's expense any damaged waterstops, which in the opinion of the Supervisor, have been damaged to such an extent as to affect the serviceability of the waterstops. All waterstops shall be protected from oil, grease and curing compound.

2.9.2 Material

PVC waterstops shall be fabricated from a compound, the basic resin of which shall be domestic virgin PVC. No reclaimed PVC or manufacturer's scrap shall be used. The compound shall contain all additional resins, plasticizers, stabilizers, or other materials needed to ensure that, when the material is compounded, the finished product will have the required physical characteristics listed in the ASTM or similar.

2.9.3 Fabrication

All waterstops shall be moulded or extruded in such a manner that any cross section will be dense, homogeneous and free from porosity and other imperfections.

2.9.4 Installation

Installation of the waterstops shall be in accordance with these specifications and the manufacturer's recommendations. The location and embedment of waterstops shall be as shown on the Plans, with approximately one-half of the width of the waterstop embedded in the concrete on each side of the joint.

In order to eliminate faulty installation that may result in joint leakage, particular care shall be taken that the waterstops are correctly positioned and secured during installation. All waterstops shall be installed so as to form a continuous watertight diaphragm in the joint unless otherwise shown.

Adequate provision shall be made to completely protect the waterstops during the progress of the work.

Concrete surrounding the waterstops shall be given additional vibration, over and above that used for adjacent concrete placement, to assure complete embedment of the waterstops in the concrete. Larger pieces of aggregate near the waterstops shall be removed by hand during embedment to assure complete contact between the waterstop and the surrounding concrete. Where splices are required between waterstops of different sizes, the splices shall be made as recommended by the manufacturer of the waterstop.

2.10 Waterproofing Protective Coating for Water Retaining Structures

2.10.1 Description

This coating shall be a surface-applied material which waterproofs and protects concrete in depth and shall be suitable for use in water retaining structures. It consists of rapid-hardening Portland cement, specially treated quartz sand, and a compound of active chemicals. It is supplied in powder form and needs only to be mixed with water prior to application.

- Preparation of substrate

All concrete to be treated with this coating must be clean and have an "open" capillary system. Laitance, dirt, grease, etc. should be removed by means of high-pressure water jetting, wet sandblasting or wire brushing. Faulty concrete in the form of cracks, honeycombing etc. should be made good. Surfaces must be carefully pre-watered prior to the application of the coating. The concrete surface must be damp but not wet.

- Mixing

The powder material is mechanically mixed with clean water to a consistency of thick oil paint. Approximate mixing ratio is 0.8 parts water to 2 parts powder (by volume).

Materials mixed shall be as can be used within 20 minutes. Mixture should be stirred frequently. If mixture starts to set, no water should be added, the mixture should be stirred to restore workability.

- Application

The mix is applied by masonry brush or appropriate power spray equipment. When two coats are specified the second coat shall be applied while the first coat is still "green".

- Post Treatment

The treated surfaces should be kept damp for a period of five days and must be protected against direct sun, wind and frost by covering with polythene sheeting, damp hessian or similar.

- Safety

The use of rubber gloves and goggles during mixing and application is recommended.

2.10.2 General Requirements

Waterproofing material shall be applied to interior concrete surfaces.

It is made of cement base, sand, and other chemical. It is composed of two contents:

- Powder: Mixed of cement and other mixes as specified by the Supervisor
- Liquid: Resin base and other mixes as specified by the Supervisor

The above product must be:

- Waterproofing
- Weather and chemical product resistant

Before placing waterproofing on concrete surfaces, mastic of hydraulic cement base shall be used in concrete holes and cracks which provides a complete blockage to water. This mastic is a mixture of powder placed in special can closed tightly and shall be mixed with water before usage as directed by the Supervisor.

2.11 Bituminous Coating for Buried Walls

This material shall be applied on the exterior side of the concrete elements buried surfaces.

Ground water should be checked previously by the Contractor for chemicals which may have a deleterious effect on the structure or internal finishes.

The Contractor must obtain the previous approval of the Supervisor on the support as well on the type of material proposed.

The bituminous coating for damp-proofing should be cold applied emulsion in two coats (of at least 0.750 kg/m2 each) and cross applied.

Bitumen primer should be of the same cold bitumen emulsion compound diluted to 50% with water and applied at a minimum rate of 0,400 kg/m2. the damp-proof bituminous coat shall be applied around 24 hours after the primer application.

3 Execution

3.1 General

All waterproofing, insulation and roofing works shall be carried out in conformity with relevant European Standards.

3.2 Covering and Roof Waterproofing

A. Roof waterproofing

The roofs shall be well cleaned. All concrete or steel reinforcement defect shall be adequately repaired before the application of any waterproofing material.

The roofs shall be waterproofed by means of watertight layers and treated as specified hereinafter.

- Applying a deep penetrating polyurethane (pre-polymer) primer
- Applying waterproofing polyurethane membrane, highly permanent elastic and having excellent thermal resistance.
- For uncovered/unprotected waterproofing membranes, an aliphatic polyurethane top-coat shall be applied, UV -stable, allowing domestic pedestrian access.

- Flood test the roof area after applying the roofing membrane, for a period not less than 72 hours, to a height that is not less than 300-mm. Observe for any leaks, and note the observations in a written inspection report.
- A full system warranty to be provided, that includes all parts of the roofing built-up system, including accessories, for a period that is not less than 10 years from date of substantial completion.

Before rendering the roof waterproof, a thermal insulation shall be laid consisting of 5 cm polystyrene foam, laid on a vapour barrier of 2/10 mm thick PVC sheet. Slabs of polystyrene foam shall be carefully placed without any gap.

B. Heat Insulation

Before rendering the roof waterproof, a thermal insulation shall be laid above the roof waterproof membrane, separated by a 250 g/m² unwoven geotextile protection. The thermal insulation consists of 5 cm extruded polystyrene foam board. Slabs of polystyrene foam shall be carefully placed without any gap. Broken slabs will not be allowed.

C. Raising

On the inside faces of the parapet walls and all around the projections of the flatroofs (stacks of smoke pipes, ventilation, air coolers, etc.), the first coating shall be bond by a cold impregnation sealant and a hot sealant application layer. The second flexible watertight coating shall be self-protected by aluminium sheeting and shall cover the inside face and the top of the parapet.

Expansion joints on the roof shall be covered with a continuous aluminium sheet, as shown on drawings. Special care shall be taken at crossing of two expansion joints.

D. Covering

All roofs shall receive over the waterproofing:

- Polyane film,
- a layer of 10/30 gravel 8 cm thick, or
- precast tiles 30 x 30, 3 cm thick made with mortar with 350 kg of cement per cubic metre of sand; tiles will be placed with thin joint filled with bitumen and over a layer of sand 3 cm thick.

E. Rain-Water Down Pipes

Drainage or rain-water will be either through outside down pipes, or down pipes embedded in a concrete column or prefabricated water spout.

Down pipes shall be made of PVC, and 125 mm in diameter. A strainer shall be provided to prevent solid substances going through. At right angles with the emptying of rain-water a lead plate 40 cm x 40 cm welded to a pipe 30 cm long connecting the down pipe shall be provided. This plate shall be situated between two coats of bitumen felt, or butyl film.

When the rain-water down-pipes are outside the building a lead plate shall be provided in order to pipe the waters down to a zinc box situated outside and fixed on the front of the buildings. From this box the rain-water down pipe shall be laid and fixed on the wall by removable pipe collars of galvanised steel.

Rain-water down pipes shall be connected to the general rain-water drainage system by means of a pit closed with a cast iron cover.

The Contractor shall submit the detailed layout of the drainage system to the approval of the Engineer.

All constructional measures shall be taken to weather-proof the facades of the structures.

SECTION 08100
ALUMINIUM DOORS AND WINDOWS – GLAZING

1 GENERAL

1.1 Work Included

This section covers the manufacturing and fixing of natural anodized aluminium external air-tight doors and windows with single or double glazing as required for the various buildings.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;
B. Section 03300 Concrete
C. Section 06400 Wood works.

1.3 Codes And Standards

ASTM A-788 Specification for Steel Forging, General, Requirements.

ASTM B-221 Specification for Aluminium Alloy Extruded Bars, Rods, Wires Shapes and Tubes.

ASTM C-158 Method for Testing Flexural Testing of Glass.

1.4 Quality Assurance

All the aluminium installation should be manufactured by a single manufacturer with a uniform finish.

1.5 General Submittals

The Contractor has to submit for approval the following:

- To submit to the Engineer manufacturer's specifications (Elastic limit, Modulus of elasticity) and installation instructions and other data to show compliance with these Specifications.
- To submit shop drawings of all components for review by the Engineer. Including full size sections of all typical members, dimensioned elevations, anchors and other accessories required.
- To submit to the Engineer sets of samples for each type, finish and color required. Sample submittal and approval shall be for color, texture and specular floss only. Compliance with all other requirements is the exclusive responsibility of the Contractor.
- To submit sample corner window unit, with hardware, representative of fabrication techniques and workmanship of the final products.

2 PRODUCT

2.1 Aluminium

Sections should be extruded from 6063-T5 aluminium alloy conforming to ASTM B-221.

2.2 Fastening Devices

All the fastening devices shall be of aluminium, stainless steel or other corrosion resistant material with sufficient strength, and if visible should blend with the frame finishes.

2.3 Hardware - General

All the hardware fixed shall be of best quality available in the market. The finish of hardware must closely match the finish of doors and windows.

2.4 Screen and Mosquito Net

All windows and ventilation openings shall be provided with insect corrosion resistant external screen and/or mosquito net.

2.5 Handle

Handle shall be brass or aluminium alloy, 100 mm long fixed with screws of the same material.

2.6 Lock

At least all external doors shall be capable to be locked.

Locked doors shall be delivered with 3 keys.

Lock shall be automatic dead locking mortise lock with 2 bevelled latches and handles.

2.7 Stopper

When required, doors shall be fitted with foot-operated friction door stoppers.

2.8 Hydraulic Door Closer

When required, doors shall be fitted with single-action type, face fixing hydraulic door closer.

2.9 Hinge

Hinge shall be brass built hinge of size 100 x 50 mm or extra heavy steel-butt-hinge of size 130 x 80 mm depending of the size of the door.

When shown on the Drawings or directed, doors shall be fitted with double-action oxidised brass, sprint-butt-hinge of size 100 x 50 mm.

2.10 Glass

All the glass shall comply with the appropriate section of ASTM C-158.

Sheet glass shall be colourless free from bubbles, distortion and flaws of other significant nature. The glass shall be properly cut to fit the rebates so as to have a uniform space to accommodate rubber insertion all-round the panel between edge of the glass and the rebate.

Plain glass is usually the type to be used for windows, doors, etc. unless otherwise directed. Its minimum thickness shall be 6mm. However, the thickness shall be defined and approved by the Engineer depending on the panel's dimensions.

The breaking strength under flexural load shall be not less than 30 MPa. It shall withstand 24 hours exposure to hydrochloric acid vapour and subsequent return to open air without impairment of either its transparency clearness or lustre.

Where phonic insulation is required, glasses shall have an acoustic absorption factor of 32 dB over the range 100 to 3200 Hz.

Unless otherwise agreed, glass blades for louvres shall be 150 mm wide with 25 mm overlaps and shall have polished edges.

Where the total length of a louvre exceeds 1100 mm, mullions shall be incorporated in the frame so that no louvre blade is larger than 1100 mm.

The blades shall be set into interlocking metal clips fixed to the frames. The clips and the frames shall be of aluminium.

Head and cell sections of the louvre frames shall match and be fitted with dual softness PVC or neoprene insert weatherstrips

2.11 Glass Products

The below glass products could be selected for different building and different exposures. The type selection should be confirmed and approved by the Engineer

2.11.1 Ordinary Glass

The glass shall be of a quality approved by the Engineer, and shall be 6mm thick. It shall be free of air bubbles, scratches, streaks, undulations or any other defects. It shall not deform the image showing through or reflected on it. In particular, objects seen crosswise, at a distance of 0.25m and an angle of 20 degrees, shall not be deformed.

The Contractor shall submit to the Engineer for approval samples of the glass to be used. Glass shall be cut to the exact measurements by taking into account possible dilation (the play between the glass and the framework shall not exceed 2mm). The panes shall be set up under mastic strips or as indicated on the drawings. The mastic shall be of the white mastic type with pure linseed oil. The use of bituminous mastic is forbidden.

Wedging of the glass is obligatory.

After execution of all works, the Contractor shall proceed to clean the glass on both sides and to remove all wastes resulting from the said works.

The glass shall be transparent, translucent, or of a special type.

All glazing in windows and doors shall be polycarbonate sheeting (purpose made for anti-vandal and security use), obtained from an approved manufacturer.

The glazing sheets, extruded from polycarbonate resin, shall be a minimum of 4 mm thick. The polycarbonate sheets shall be installed in the frames in strict accordance with the manufacturer's recommendations and only sealant specified by the manufacturer shall be used.

2.11.2 Primary Glass

The Contractor shall provide primary glass which complies with ASTM C 1036 requirements, including those indicated by reference to type, class, quality, and, if applicable, form, finish, mesh and pattern.

A. Clear Float Glass: Type I (transparent glass, flat), Class I (clear), Quality q3 (glazing select).

B. Tinted Float Glass: Type I (transparent Class, flat), Class 2 (tinted heat absorbing and light reducing), Quality q3 (glazing select):

   1. Refer to coated glass product requirements for tint and performance characteristics of coated tinted glass for single. glazing, relative to visible light transmittance, U- values, -shading coefficient and visible reflectance.

   2. Refer to requirements for sealed insulating glass units for performance characteristics of assembled units composed of tinted glass. coated or uncoated, relative to visible light transmittance, U-values, shading coefficient and visible reflectance.

C. Wired Glass: Type II (patterned and wired class, flat), Class I (translucent), Quality q8 (glazing); complying with ANSI Z97.1- 6 mm thick; of form and mesh pattern indicated below:

   1. Polished Wire Glass: Form I (wired, polished both sides), Mesh m2. (square).

2.11.3 Heat-Treated Glass

The Contractor shall provide heat-treated glass which complies with ASTM C 1048 requirements, including those indicated by reference to kind, condition, type, quality, class, and, if applicable, form, finish, and pattern.

The Contractor shall provide manufacture heat-treated glass as follows:

By vertical (tong-held) or horizontal (roller hearth) process, at manufacturer's option, except provide horizontal process where indicated as "tongless" or "free of tong marks".

Uncoated Clear Heat-Treated Float Glass: Condition A (uncoated surfaces), Type I (transparent glass, flat), Class I (clear), Quality q3 (glazing select), kind as indicated below:

1. Kind HS (heat strengthened) where recommended by glazing manufacturer.
2. Kind FT (fully tempered) at all doors, sidelights and glazing units below 1050mm.

Uncoated Tinted Heat-Treated Float Glass: Condition A (uncoated surfaces), Type I (transparent - lass, flat), Class 2 (tinted heat absorbing and light reducing), quality q3 (glazing select), with tint color and performance characteristics for 6mm thick glass matching those indicated for non-heat-treated tinted float glass; kind as indicated below:

1. Kind HS (heat strengthened) where recommended by glazing manufacturer.
2. Kind FT (fully tempered) at all doors, sidelights, and all glazing units below 1050mm.

Uncoated Etched Heat-Treated Float Glass: Condition C (other coated Class). Type I (transparent glass, flat), Class 2 (tinted heat absorbing and light reducing). Quality q3 (glazing select), with coating type and performance characteristics complying with requirements specified under coated glass products; kind as indicated below:

1. Kind FT (fully tempered).
2. Etched Pattern: Sandblast glazing units on one or both surfaces of pattern.
3. Provide clear etched glass sealer on all sandblasted glass types.

Ceramic-Coated Heat-Treated Spandrel Glass (Interior Conditions): Condition B (spandrel glass, one surface ceramic coated), Type I (transparent glass, flat), Class I (clear), Quality q3 (glazing select), with ceramic coating applied to second surface and complying with the following requirements:

1. Kind HS (heat strengthened), where recommended by glazing manufacturer.
2. Kind FT (fully tempered) at all doors, sidelights and glazing units below 1050mm.
3. Color: Match Engineer's custom color.

2.11.4 Laminated Glass

A. General: Refer to primary and heat-treated glass require properties of uncoated glasses making up laminated glass products.

B. Plastic Interlayer: Provide glass fabricator's standard polyvinyl butyral interlayer for laminating panes of class, with a proven record of showing no tendency to bubble, discolor or lose physical or mechanical properties after laminating and installation, in clear or colors and of thickness indicated.

C. Laminating Process: Fabricate laminated glass using laminator's standard heat-plus-pressure process to produce glass free from foreign substances and air/glass pockets.

D. Laminated Safety Glass: Two panes of glass of equal thickness, laminated together with not less than 0.76 mm thick plastic interlayer and complying with requirements indicated below:

1. Glass Characteristics: Float glass, complying with requirements for class, tint, kind and thickness of each pane (ply) indicated below:
    a) Class 1 - clear for both panes.
    b) Class 2, gray tint, outer pane only.
    c) Kind HS (heat strengthened), where recommended by manufacturer.
    d) Thickness: 6 mm unless otherwise indicated.
2. Color of Plastic Interlayer: Clear.
3. Provide etched glazing units that match Engineer's sample in areas indicated on Drawings.

2.11.5 Sealed Insulating Glass Units

This glass type shall be applied on all facades.

The Contractor shall provide preassembled units consisting of organically sealed panes of glass enclosing a hermetically sealed dehydrated air space and complying with ASTM E 774 for performance classification indicated as well as with other requirements specified for glass characteristics, air space, sealing system, sealant, spacer material, comer design and desiccant.

The Contractor shall provide heat-treated panes of kind and at locations indicated or, if not indicated, provide heat-strengthened panes where recommended by manufacturer for application indicated and tempered where indicated or where safety glass is designated or required.

Performance characteristics designated for coated insulating glass are nominal values based on manufacturer's published test data for units with 6 mm thick panes of glass and 12 mm thick air space.

Performance Classification per ASTIM E 774: Class A.

Thickness of Each Pane: 6 mm.

Air Space Thickness: 12 mm.

Sealing System: Manufacturer's standard.

Spacer Material: Aluminium.

Desiccant: Manufacturer's standard; either molecular sieve or silica gel or blend of both.

Corner Construction: Manufacturer's standard corner construction.

1- Low Emissivity-Coated Insulating Glass Units:

Manufacturer's standard units with one pane of glass coated with a durable, neutral-colored, low-emissivity metallic coating, of type and on surface indicated, and complying with the following requirements.

Exterior Pane: Tinted float glass, coated on second surface.

a) Tint: Gray.
b) Kind HS (heat strengthened), where recommended by manufacturer.
c) Kind FT (fully tempered), at all doors, sidelights and glazing units below 1050mm.

Interior Pane: Clear float glass, uncoated.

Coating type: Vacuum deposited.

Performance Characteristics: Visible transmittance of 26 percent, summer daytime U-value of 1.82 W/ (m2 K) [0.321, winter nighttime U- value of 1.7 W/ (m2.K) [0.30], shading coefficient of 0.30 and outdoor reflectance of 9 percent.

2- Sloped Insulating Glass Units:

Provide manufacturer's standard insulating units with interior pane of laminated sloped glass and with exterior pane complying with requirements indicated below:

1. Kind HS (heat strengthened), tinted float glass.
2. Provide units with ceramic frit coating of pattern indicated on Drawings.
3. Units Performance Characteristics: Visible light transmittance of 30%, overall U-value of 2.27 W/ (m2.K) [0.40] and shading coefficient of 0.36.

3- Sloped Insulating Glass Units (Control Tower):

Provide manufacturer's standard insulating units with interior pane of laminated sloped glass and with exterior pane complying with requirements indicated below:

1. Tint: Green
2. Kind: HS/FT, where recommended by manufacturer.
3. Thickness: 10 mm
4. Units Performance Characteristics: Visible light transmittance of 0.53, summer daytime U-value of 3.18 W/ (m2.K) [0.56], winter night-time U-value of 2.78 W/(m2.k) [0.49], shading coefficient of 0.40 and outdoor reflectance of 0.09.

4- Insulating Spandrel Glass:

Manufacturer's standard units with Kind HS (heat strengthened) exterior pane and location of reflective coating matching that of coated insulating glass units for type, class and coating characteristics, and with interior pane complying with the following additional requirements:

5- Ceramic-Coated Heat-Treated Spandrel Glass:

Condition B (spandrel glass, one surface ceramic coated), Kind HS (heat strengthened), Type I (transparent glass, flat), Class I (clear), Quality q3 (glazing select), and complying with the following requirements:

a) Color Match Engineer's sample.

b) Location of Ceramic Coating: Third surface of insulating spandrel unit. Overall U-value: 0.45 W/ (m2.K), [0.08].

2.11.6 Elastomeric Glazing Sealants and Preformed Glazing Tapes

The Contractor shall provide products of type indicated and complying with the following requirements:

1. Compatibility: Select glazing sealants and tapes of proven compatibility with other materials with which they will come into contact, including glass products, seals of insulating glass units, and glazing channel substrates, under conditions of installation and service, as demonstrated by testing and field experience.
2. Suitability: Comply with recommendations of sealant and glass manufacturers for selection of glazing sealants and tapes which have performance characteristics suitable for applications indicated and conditions at time of installation.
3. Elastomeric Sealant Standard: Provide manufacturer's standard chemically curing, elastomeric sealant of base polymer indicated which complies with ASTM C 920 requirements, including those for Type, Grade, Class and Uses.
4. Colors: Provide color of exposed sealants indicated or, if not otherwise indicated, as selected by Engineer from manufacturer's standard colors.

One-Part Non-Acid-Curing Silicone Glazing Sealant: Type S; Grade NS, Class 25; Uses NT, G, A, and, as applicable to uses indicated, 0; and complying with the following requirements for modulus and additional joint movement capability.

1. Low Modulus: Tensile strength of 172 kPa [45 psi] or less at 100 percent elongation when tested per ASTM D 412 after 14 days at 25 degree C and 50 percent relative humidity.
2. Additional capability, when tested per ASTIM C 719 for adhesion and cohesion under maximum cyclic movement, to withstand the following percentage increase and decrease of joint width, as measured at time of application and remain in compliance with other requirements of ASTM C920.

   a) 40 percent.

   Preformed Butyl-Polyisobutylene Glazing Tape: Provide manufacturer's standard solvent-free butyl-polyisobutylene formulation with a solids content of 100 percent; complying with AAMA A804.1; in extruded tape form; non-staining and non-migrating in contact with nonporous surfaces; packaged on rolls with a release paper on one side; with or without continuous spacer rod as recommended by manufacturers of tape and glass for application indicated.

2.12 Glazing Beads and Gaskets

Metal glazing beads shall be supplied with the metal frame and shall be tightened with sunken screws.

All aluminium doors and windows shall have locking glazing beads and extruded gaskets made of Thermoplastic Polyolefin Rubber (TPV).

2.13 Miscellaneous Glazing Materials

A. Compatibility: Provide materials with proven record of compatibility with surfaces contacted in installation.
B. Cleaners, Primers and Sealers: Type recommended by sealant or gasket manufacturer.
C. Setting Blocks: Neoprene, EPDM or silicone blocks as required for compatibility with glazing sealants, 80 to 90 Shore A durometer hardness.
D. Spacers: Neoprene, EPDM or silicone blocks, or continuous extrusions, as required for compatibility with glazing sealant, of size, shape and hardens recommended by glass and sealant manufacturers for application indicated.
E. Edge Blocks: Neoprene, EPDM or silicone blocks as required for compatibility with glazing sealant, of size and hardness required to limit lateral movement (side-walking) of glass.
F. Compressible Filler Rods: Closed-cell or waterproof-jacketed rod stock of synthetic rubber or plastic foam, flexible and resilient, with 35-69 kpa [5-10psi] compression strength for 25 percent deflection.

2.14 Doors and Windows

All windows and outside doors shall be designed to support a pressure of 1.5 kPa.

Buckling of openings: three angles of an opening being maintained fixed, a force of 100 N applied upright on the fourth free angle shall not introduce a displacement of this free angle greater than 5mm.

The openings support a vertical force of 1 kN at the top edge of the door or windows opposed to the hinges without any permanent deformation.

Standard sized doors shall operate under a force of less than 5 daN and opening windows under a force of less than 3 daN.

Lock system shall be quick and efficient with the handle at 4 cm free distance from any fixed element.

Metallic joinery shall be built from standard sections allowing a dust proof joinery with double elastomer joints.

Number of hinges shall be 2, 3 and 4 for openings height of 1.00, 1.80 and 2.50 m respectively. Hinges shall be fitted with bronze ring and the male part shall be adjustable.

- Make provisions at sill to drain water and condensation to exterior face of the frames.
- Provide tight joints and effectively seal windows against water leakage and air infiltration. Water leakage is defined as appearance of uncontrolled water, other than condensation, on any inboard part of window, either during testing or under actual weather conditions.
- Place at least 2 holes of 50 mm² each (1 hole/1m) are needed in the outside frame, against water infiltration.

2.15 Entrance Rolling Doors

Aluminum sheeting on steel framed door electrically controlled, suspended and rolling on an upper rail supported by the steel structure.

Insulation equivalent to insulation of aluminum insulated sheet walling.

Ventilation openings with screen 600 x 600 mm.

Opening for glazing 600 x 800 mm (glass equivalent to the glass used for internal windows.

Finishing equivalent to the sheet walling.

Shop drawings to be proposed to the Engineer's approval together with shop drawings for the whole buildings structural steel works and sheet walling.

2.16 Glass Blocks

Glass block walls shall be constructed from hollow glass blocks 240 x 240 x 80 mm or equivalent dimensions set in mortar in a perimeter framing to connecting walls and ceilings of aluminium channel sections.

The wall shall be set against the floor on 2 layers of bituminous felt. Channel sections shall be fixed to walls and ceilings with the concave face against the glass blocks and lined with 10 mm thick foamed polystyrene and 1 layer of bituminous felt before mortar is placed.

The glass blocks shall be set with flush joints to true horizontal and vertical lines in a 250 mm module. All channel sections shall be completely filled with mortar, and the joints between channels and mortar filled with an approved elastic joint filler.

Glass block walls shall be reinforced with 8 mm hot dip galvanized plain reinforcement bars around the perimeter and in every horizontal and vertical joint.

2.17 Rolling Shutters

Aluminium rolling shutters shall be provided for all the windows and doors, mechanical operated.

3 EXECUTION

3.1 Frame

Where practicable, frames shall be placed prior to construction of enclosing walls and ceilings.

Frames shall be securely braced into position until permanent anchors are set.

3.2 Glazing

Glazing channels, stops and rabbits shall be cleaned before receiving the glazing materials.

Glass shall be set in a manner which produces the best possible degree of uniformity in appliance.

Glass shall be protected from breakage after installation by installing streamers or ribbons attached to the framing and held free from glass.

Materials shall be stored according to the specifications that are specific to the materials used while taking all usual precautions. The Contractor remains, in all cases, responsible for all breakage. All damaged or broken glass or mirrors shall be rejected and must be replaced. When finished, cleaning up is a must.

The Contractor shall inspect work of glass framing assembling for compliance with manufacturing and installation tolerances, including those for size, squareness, offsets at corners; for presence and functioning of weep system; for existence of minimum required face or edge clearances; and for effective sealing of joinery. The Contractor shall not allow glazing work to proceed until unsatisfactory conditions have been corrected.

The Contractor shall also clean glazing channels and other framing members to receive glass, immediately before glazing. Remove coatings which are not firmly bonded to substrates. Remove lacquer from metal surfaces where elastomeric sealants are indicated for use.

The Contractor shall comply with combined printed recommendations of glass manufacturers, of manufacturers of sealants, gaskets and other glazing materials, except where more stringent requirements are indicated, including those of referenced glazing standards.

Protect glass from edge damage during handling and installation; use a rolling block in rotating glass units to prevent damage to glass corners. Do not impact glass with metal framing, use suction cups to shift glass units within openings; do not raise or drift glass with a pry bar. Rotate glass with flares or bevels along one horizontal edge which would occur in vicinity of setting blocks so that these are located at top of opening. Remove from project and dispose of glass units with edge damage or other imperfections of kind that, when installed, weakens glass and impairs performance and appearance.

Apply primers to joint surfaces where required for adhesion of sealants, as determined by preconstruction sealant-substrate testing.

3.3 Painting of Metal Work

All metal works shall be shop painted.

3.4 Cleaning

Glass shall be cleaned with methylated spirit on completion.

3.5 Construction Requirements

3.5.1 Aluminium Finishes

Remove die markings prior to finishing operations. Where necessary to remove die markings from any part of the work, all members must be finished by the same process, whether or not die marking exists. Perform this work in addition to the finish specified. Scratches, abrasions, dents and similar defects are unacceptable.

All exposed aluminium surfaces shall be of anodized aluminium.

3.5.2 Condition of Surfaces

Examine the substrates and adjoining construction and conditions under which the work is to be installed. Do not proceed with the work until unsatisfactory conditions detrimental to the proper and timely completion of the work have been corrected.

3.5.3 Installation

Vary dimensions of openings by field measurements so that aluminium windows will be accurately designed, fabricated and fitted to the structure.

Coordinate aluminium windows, with the work of other trades and provide items to be placed during the installation of other work. Check the location of such items and verify that they have been set accurately in relation to the final location of windows.

Erect the windows, in accordance with the manufacturer's written instructions and recommendations. Employ only experienced erectors.

Erection Tolerances: Erect aluminium window within the following tolerances:

1. Variation from plumb: 3mm maximum.
2. Variation from level: 3mm maximum.

Cut and trim component parts during erection only with the approval of the manufacturer or fabricator and in accordance with his recommendations. Do not cut through reinforcing members. Restore finish completely to protect material and remove all evidence of cutting and trimming. Remove and replace members where cutting and trimming have impaired strength or appearance.

Do not erect members which are observed to be warped, bowed, deformed or otherwise damaged or defaced to such extent as to impair strength or appearance. Remove and replace members damaged in the process of erection, as directed.

Set units level, plumb, and true to line, with uniform joints. Support on metal shims and secure in place bolting to clip angles and similar supports anchored to supporting structure. Use only the types of equipment, ropes, wedges, spacers, shims and other items during erection which will not stain or mark the finish of units.

The slat-holders of louvers shall not rub on the frames and shall present a good tightness when closed with the frames. The rigidity of the slat-holders shall be ensured independently from the glass. Once the slats are installed and the jalousies closed, no play shall be tolerated between two blades. Pivots and axes shall be of the best quality and shall be mounted according to the rules of the art. They shall be, as well as their fixing screws, made of chromium-plated steel or of a special stainless alloy. The aluminium screws shall not be accepted.

Paint concealed contact surface of dissimilar materials with a heavy coating of bituminous paint, or provide other separation as per manufacturer's recommendations.

Solder and braze only to fill or seal joints (not to form structural joints), and in accordance with components parts manufacturer's recommendations. Grind smooth and restore finish.

Paint clip angles and other ferrous metal parts which will be concealed, with zinc chromate paint.

Seal joints in a concealed manner, unless exposed sealant is shown.

Adjust ventilators and hardware to provide a tight fit at contact points and at weather stripping. Lubricate hardware and other moving parts.

3.5.4 Isolation of Aluminium

All items of aluminium construction shall be isolated from concrete by the use of bituminous felt or DPC material or two coats of bituminous paint. The aluminium shall be isolated from dissimilar metal by the use of fiber washers and spacers.

3.5.5 Protection and Cleaning

In addition to specific protection and cleaning methods required for each component part of the respective Sections of the specifications and recommended by the respective manufacturers, maintain the work throughout the construction period in a clean and properly protected condition that it will not be damaged at the time of completion of the works.

Cleaning and protective methods shall be carefully selected applied and maintained so that finishes will not become uneven or otherwise impaired as a result of unequal exposure to light and weathering conditions.

Remove deleterious materials from surfaces of aluminium immediately.

SECTION 08200
PAINTING

1 GENERAL

1.1 Work Included

1. Surfaces indicated to be painted on the Drawings.
2. Surfaces as directed by the Engineer.

1.2 Related Sections

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 01010 - Corrosion protection

C. Section 04000 - Masonry works

D. Section 06400 - Wood works.

1.3 Standards

Society for Protective Coatings (SSPC) Specifications, or equivalent

1.4 Quality Assurance

Adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and methods needed for proper performance of the work of this Section shall be used.

1.5 Submittals

The Contractor shall submit 4 months before the scheduled date of painting 3 colour schedules of painting together with a description of colour codes, composition and manufacturer's recommendations concerning preparation of the surface and method of application of the paint of each type of paint and each type of exposure condition, as directed by the Engineer.

1.6 Sample Areas

Sample areas of not less than 1.50 m x 1.50 m shall be prepared and painted, one for each colour and/or type of surface finish as required or as directed by the Engineer.

If approved by the Engineer the sample areas will serve as minimum reference standards for painting.

1.7 Description of Work

The rooms will include the following interior painting works:

- Epoxy paint: Dust-resistant, non-slip, washable and acid-resistant paint on floors with 10 cm run-up on interior walls in all electrical and technical rooms and in all workshop and store rooms, including deodorization and chemical/ reagent storage rooms.
- Two coats of glyptal paint on all interior walls and ceiling in technical electrical and equipment rooms and in deodorization and chemical/reagent storage rooms.
- Gloss paint to be applied for all ceilings and interior walls in workshop and storage rooms (Excluding deodorization and chemical/reagent storage rooms).

- Appropriate epoxy paint to be applied on all walls and ground faces and ceilings (where applicable) inside all concrete water and wastewater tanks and pump pits.
- Appropriate epoxy paint shall be applied on all exterior faces of all concrete structures (Where stone cladding is not applied), due to the exposure to the sea salt sprays and the risks of wastewater chemical fumes (Even though odour treatment is provided).
- Appropriate colourless epoxy paint to be applied on the stone cladding for protection.
- The internal walls and ceilings finish inside administration buildings, accommodation building, guard house buildings include the usage of tiling, acrylic and gloss paints, as specified in the performance specifications document, while the floor is covered by ceramic tiles.

For the specifications related to the floor tiling and stone cladding, refer to section 082500.

High quality paint shall be submitted for approval for each finishing type, including related method statement and data sheets, justifying the material adequacy to rooms usage and faces exposure.

1.8 Delivery, Storage and Handling

Paint materials shall be delivered in sealed original labelled containers, bearing manufacturer's name, type of paint, brand name, colour designation and instructions for mixing and/or thinning down.

All paints and associated materials shall be stored in dry covered storage which is adequately ventilated and protected from temperature extremes. Any paint which is, in the opinion of the Engineer, not in good original conditions according to manufacturer's specifications, shall be replaced by the Contractor at his own expense.

Precautionary measures shall be taken to prevent fire hazards and spontaneous combustions.

1.9 Environmental Requirements

Blast cleaning and painting work shall be carried out only when the ambient air and degree of humidity are within the requirements of the instructions for use of the product.

Paints shall be applied only to surface that are thoroughly dry and under such conditions of humidity and temperature as will cause evaporation rather than condensation. The surface temperature shall always be at least 3□C higher than the dew point.

Generally, all work shall be suspended as soon as the degree of humidity exceeds 75% and the ambient temperature exceeds 40□C or drops below 5□C.

Adequate continuous ventilation shall be maintained before, during and after application of paint up the time of the paint if thoroughly dry.

Paint when applied shall be at approximately the same temperature as the surface on which it is applied.

2 PRODUCT

2.1 General

The type and quality of paint to be incorporated in the Works will be nominated by the Engineer, and only those products approved by the Engineer shall be accepted.

All materials shall be proven, first grade products and shall meet or exceed the average standards of reputable local manufacturers.

3 EXECUTION

3.1 Inspection

The Contractor shall thoroughly examine surface scheduled to be painted prior to commencement of work.

Defects and deficiencies in surface which may adversely affect work shall be corrected.

3.2 Protection

The Contractor shall adequately protect other surface from paint and damage and shall repair damage to other surface as a result of inadequate or unsuitable protection. This shall include furnishing sufficient shields and protective equipment to prevent spray or dropping from fouling surfaces not being painted and particularly surfaces within storage and preparation areas.

Cotton waste, cloths and materials which may constitute a fire hazard shall be placed in closed metal containers and removed daily from Site.

Fittings and fastenings shall be carefully removed prior to painting operations. These items are to be carefully stored, cleaned and replaced on completion of work in each area.

3.3 Preparation

3.3.1 General

1. Surfaces to be painted shall be clean before applying paint or surface treatments. All oil, grease, dirt, rust, loose materials and other foreign substances shall be removed.
2. No coating work shall begin before the prepared surfaces, or the manner of preparation, have been approved by the Engineer.
3. Cleaning and painting shall be so programmed that dust or spray from the cleaning process will not fall on wet, newly painted surfaces.
4. Where required, imperfections and holes in surfaces shall be filled or obliterated in an approved manner.
5. Hardware, electrical fixtures and similar accessories shall be removed during preparation and painting operations and shall be replaced upon completion of painting operations.

3.3.2 Concrete and Masonry Surface

1. New concrete surface receiving paint shall be cured for a minimum of 28 days before being painted.
2. The Contractor shall remove contamination and shall acid etch and rinse new concrete floors with clear water, ensuring acid alkali balance is achieved.
3. The Contractor shall remove dirt, loose mortar, scale, powder, and other foreign matter from concrete and concrete block surfaces which are to be painted or to receive a clear seal.
4. Oil and grease shall be removed with a solution of tri-sodium phosphate, which shall then be thoroughly washed and drained from the surface.
5. Hairline cracks, small holes and imperfections on plaster surfaces shall be filled with patching plaster and the surface shall be smoothed to match adjacent surfaces.

3.3.3 Wood Surface

1. Wood surface shall be planned or sanded to remove all tool marks.

2. All holes, cracks and depressions shall be cleaned out and overfilled with non-shrinking wood filler which, when completely set, shall be sanded back to match the adjacent surfaces.

3.3.4 Plaster

1. Plaster shall be at least 2 months old and shall be thoroughly dry, clean, and free from grit, loose plaster, and surface irregularities before paint is applied.
2. Cracks and holes shall be repaired with patching plaster.
3. All plaster surfaces shall be tested for the presence of alkali which, if present, shall be removed with a solution of zinc sulphate mixed in the proportion of 1 kg to 2 litres of water. After drying, the precipitate shall be removed by brushing.

3.3.5 Applications

No paint or other products may be applied until the surface has been prepared to the satisfaction of the Engineer and until the surface is completely dry.

Each coat of paint is to be slightly darker than the preceding coat unless otherwise approved by the Engineer.

Each intermediate coat is to be lightly sanded back before the application of the subsequent coat.

The paint shall always be thoroughly mixed according to the manufacturer's instructions prior to application and only approved thinners may be used.

The time between coats shall not be less than that recommended by the manufacturer.

Any painting considered to be unsatisfactory by the Engineer shall be sanded back and repainted at the Contractor's expense.

3.4 Cleaning

During painting the work area shall be kept clean and free of dust or other harmful substances.

On completion of painting the whole area shall be thoroughly cleaned or any splashes, spills or runs.

3.5 Dry Film Thickness

The protective paint systems shall be applied in continuous films to give, at the minimum, the total dry thickness indicated in the coating schedule, as measured by approved methods.

One steel material wet thickness gauges shall be used continuously by the applicator during application to ensure that the dry thickness requirements will be met.

3.6 Coating Schedule

The following coating schedule shall be adopted:

a) Wooden frames, doors

- ~ Surface preparation: as specified.
- ~ Prime coat: plasticised nitrocellulose sealer (2:) (such as NC Wood Sealer).
- ~ Finish coat: plasticised nitrocellulose topcoat (3:) (such as NC Glossy Wood Finish).

a) Concrete and plaster

- ~ Surface preparation: as specified.

1. Acrylic Emulsion Paint
   - Prime coat: Acrylic alkali resisting masonry sealer

- Finish coat: Acrylic emulsion paint.

2. Hard Gloss Enamel Paint
   - Long oil alkyd resin paint
3. Glyptal Paint
   - Alkyd enamel resin paint
4. Epoxy Paint: Oil Repellent Paint and Concrete exposed to chemical action or heavy duty
   - In cracks and holes: epoxy sand mortar
   - Prime and finish coat: epoxy paint

No painting shall be applied to aluminium, stainless steel, copper bronze, chromium, nickel, brass or galvanized surfaces, unless directed by the Engineer.

SECTION 082500
TILING

1 GENERAL

This section deals with technical requirements for the design, manufacture, delivery, off-loading and erection of the miscellaneous suspended ceilings.

Tiles and cladding plates shall be perfectly plane (no warping shall be tolerated) and shall have exactly the required specified dimensions.

All defects in the work shall be repaired by the Contractor as directed by the Engineer.

The Contractor shall not begin work before the approval of the Engineer and after finishing all necessary civil works.

The Contractor shall leave openings for sanitary, electrical works and others as specified on the drawings or as required by the Engineer.

The area shall be clean from dirt before placing any mortar for tiling.

Tile skirting shall be placed correctly so they will cover tile edges without leaving gaps. The thickness of the concrete bed beneath skirts shall be 1 cm. at least after skirts have been placed.

The Contractor shall make sure that all work shall be executed by a competent and experienced tile layer.

Laying may not proceed in temperatures exceeding 35 degrees C except with the approval of the Engineer. Laying may then only proceed under temporary shades.

All tiling shall be thoroughly soaked in clear water for at least 2 hours prior to laying.

Before laying commences, all tiling shall be checked for size to ensure a correct fit into the area chosen for the day's laying schedule.

The concrete or floor screed sub-base shall be cleaned of dirt, dust and loose particles, and saturated with clean potable water several hours before placing the setting bed. About one hour before placing the setting bed, any surface water shall be removed.

About 15 minutes prior to placing setting bed a slush coat of cement grout 1.5 mm thick shall be applied to the sub-base. The slush coat shall be applied by trowel or brush in a limited area in order to avoid drying out.

The setting bed (cement and sand screed, 1:4 nominal mix) shall be level in plan or uniformly slopped for drainage as shown on floor plans. The screed shall be mixed and placed in limited amounts prior to the initial set of bed.

In general, the tiles material shall be as below:

- Ceramic tiles for the floors, walls and skirtings
- Marble tiles for the treads, risers and thresholds.
- Local stone for exterior walls cladding.

High quality tiles/cladding shall be provided

1.1 Materials

Portland cement: Shall comply with the requirement of BS 12 ordinary and rapid hardening Portland blast furnace complying with BS 146 high alumna cement complying with BS 915. Cement used in preparation for Mortar for bedding Marble slabs shall be Portland White Cement to BS 12.

Sand for floated coat: shall comply with the requirements of BS 1199, of BS 1198: 1200 building sands from natural sources; Table 1.

For cement-sand bedding mix, sand or crushed rock should be clean, moderately sharp not too fine and free from clay, organic and soluble matter.

Lime: shall comply with the requirement of BS 890 " Building Lime " and should be properly hydrated.

Water: shall be fresh clean drinkable and complying with the requirement of BS 3148.

Reinforcement: Where required for flooring or screed it shall be expanded metal (10 mm. to 20 mm. mesh) complying with BS 405 expanded metal; or wire netting (1 mm. to 25 mm. mesh) complying with BS 1485 galvanised wire netting.

Cement based adhesive: Shall comply with B.S.C.P. 212 Part 1. Appendix (B).

Mastic adhesive: Shall comply with B.S.C.P. 212 Part 1. Appendix (A).

Metal anchorages: Should be made of suitable non-ferrous metal e.g. Copper, Phosphor-Bronze, Gun metal or other approved metal. They shall be of such shape, dimension and strength and properly fixed to the wall and to the marble sand stone that they are adequate to carry the loads and stresses to be imposed on them.

Brass and Bronze cramps, ties and connections for wall cladding and other elements shown on drawings shall conform to the applicable requirements of BS 2870, rolled copper and copper alloys.

Floor dividing strips: Shall be non-corrosive metal as shown on drawing and shall be used at the junction between different floor finishing.

The profile shall be uniform in size and capable of being cut, drilled and where necessary around the profile shall be adjustable to level tolerances in the slab.

1.2 Product Delivery, Storage and Handling

The Contractor shall transport, handle and store all materials with proper equipment, and in a manner to prevent soiling, staining and damage. Any damaged, broken, or permanently stained products will be replaced at the Contractor's expense.

1.3 Workmanship

1.3.1 Surface Preparation

Before laying any kind of tiles on floor screed or plastered walls, the surfaces shall be thoroughly cleaned of all dust and sand. Extra Mortar shall be knocked off with a hammer and removed. The surfaces shall be profusely sprayed with water and allowed to drain.

1.3.2 Laying Screed

Screed battens carefully levelled and trued should be fixed at the correct height for the required thickness of screed. In hot or drying weather care should be taken to ensure that portland cement mixes do not stiffen or dry out to an extent that prevents full compaction. After compaction, the surface must not be allowed to dry out quickly and protection by plastic sheeting or other suitable means may be necessary.

A base make-up slab may be laid, bonded to the structural slab with a PVA type bonding agent, and the floor tiles bedded on the make-up slab using a pre-mixed rubber-latex: cement mortar.

These mortars are specialist mortars with the manufacturer's instructions.

1.3.3 Mortar

Mortar for setting and backing up shall be cement and sand (1:4) mix by volume of white, non-staining Portland cement mixed to a stiff consistency. Do not use mortar if more than 2 hours has elapsed since initial mixing.

Mortar bed shall be placed in specified locations with accurate thickness and measures as shown on the drawings or as required by the Engineer.

Mortar bed shall be poured and leveled with a leveling rod. The leveling rod shall be flat and clean. The percent water in the mix shall be adequate not to leave a foam on the surface of the layer after spreading it.

The Contractor shall verify with the Engineer whether the strength additives he wishes to mix with the concrete is applicable for use and shall also provide the name of the manufacture.

White cement grout for joints shall be from the best quality and approved by the Engineer.

Sand to be used for the mix shall conform to the requirements of sand specification.

1.3.4 Floated Coat

Floated coats of Portland cement and sand (1:4) mix with a total thickness to be 1.5 cm applied on the whole surface to be tiled.

The materials should be mixed together thoroughly before adding water. Only sufficient water should be added to make the mix workable, and should be used within two hours of the addition of the water.

It is very important that the floated be plumb, true and level, any unevenness should be such that a variation of no more than 0,15 cm. In any distance of 3,00 meter is required to bring the finished tiled face to the required plane.

It is necessary to apply the floated coat in two separate operations render and float. The surface of floated coats should be left with a steel float finish.

1.3.5 Precautions

The Contractor shall make sure that tiles are immersed in clean water for 6 hours and surplus water drained off, before bedding. Tiles shall be fixed to the floating coats with an approved adhesive, in accordance with B.S.C.P 212 a true vertical joint and pointed in neat white or colored cements, any surplus which adheres to the face of the tile shall be wiped off with a damp cloth before it sets hard.

Where tiling abuts against wood or metal frames or other tiling at angles and around pipes etc... It shall be carefully cut and fitted to form a close neat joint.

Whenever specified, the sand beds shall be of the thickness necessary to make up the finished floor level. They shall be salt free.

1.3.6 Grouting

All paving shall be grouted up on completion; care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match tilling. Any surplus grout shall be cleaned off the face of the tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned.

1.3.7 Allowance for Movement

The Contractor shall give due allowance for movement of the marble slabs. Therefore, the Contractor is to take all necessary precautions in respect of these movements by providing compression and

expansion joints in his design and detailed working drawings taking into consideration the type of structural backing, climatic conditions and exposure to sun, as well as the type of marble being used.

These joints should be filled with Polysulphide mastic compound.

1.3.8 Tolerances

The height and length dimensions of individual slabs shall be worked to within plus or minus 1 mm from those specified. Thickness shall be within 3mm from the specified, except where the thickness of the slab, forms a "seen" end. In such cases the thickness must be accurate to close limits.

All blocks, concrete or other backing must be formed so as to allow 13 mm clearance (void) between it and the back of any marble slab cladding.

1.3.9 Protection

After setting, all work liable to staining and damage shall be protected with an adequate type of covering approved by the Engineer. Any paper or wood used in connection with such protection shall be free of coloring matter and shall be of an approved non-staining type. This protection shall be kept in position and in repair, and shall be removed only at the direction of the Engineer.

2 CERAMIC TILES FOR FLOORS AND SKIRTINGS

Ceramic tiles shall be of the best quality. They shall present qualities and properties of the highest standard, and in particular flatness, orthogonality, resistance to wear, porosity, etc.

They shall be resistant to acids, bases, grease and hydrocarbons. The back of the tile and skirting shall carry the type and name of manufacture.

The Contractor shall submit samples for the Engineer's approval.

Tiles shall conform to the following requirements:

- Water absorption 0.3 % max.
- Erosion: Less than 7 mm.
- Breaking Resistance: At least 150 Kg/cm²
- Sound: No hollow sounding
- Tolerance (composed of a pack of 10 pieces)

1. Width: ± 2 mm.
2. Thickness: ± 1 mm.

- Weight: Approximately 2.3
- Porosity: 0.2 max.
- Size: As shown on the drawings or as required by the Engineer with a thickness range from 9 to 10 mm.
- Exterior appearance: No defects shall be apparent

Tiles shall be laid on sand bed 7 cm. thick or more, or as shown on the plans or as required by the Engineer. The sand bed shall be saturated and compacted well.

Sand used for floors shall be of the best quality and clean of all dirt.

Tiles shall be laid on a 2.5 cm. thick mortar bed proportioned at 600 kg. of Portland Cement CPA 210/325 per cubic meter of sand. The thickness of the mortar bed shall be 2 cm. at least after tiling.

The Contractor shall place all necessary installations before tiling.

The alignment of tiles shall be attained by means of perfectly straight tight strings.

The joints of the skirting shall be aligned with those of the tiles. During tile laying, tiles shall be taped on softly to assure that they are dipped enough in the mortar.

Levelling rod and level shall be placed on top of the tiles to make sure that the alignment and levelling are correct and even in every direction.

In the case of a step in tiling, and unless otherwise shown on the plans or directed by the Engineer, the two tiles forming the angle, shall be chamfered so that the joint is along a straight line.

After the laying, circulation shall not be allowed on ceramic tiles for 4 days.

24 hours after laying the tiles, the joints shall be covered with white cement grout.

The Contractor shall take all necessary measures to ensure protection of the executed works until their receival. He shall be responsible for repairing any damage.

The Contractor shall, at the end of works, clean the tiles and skirtings with spirits of salt.

Tile works shall include all necessary tools to cut the tiles either on site or in the factory if needed. This work shall also include transporting the tiles to the factory, cutting it, and transport it back to the rooms.

Tile works shall also include all tile skirting works including mixing, transferring the sand, cement, water and all necessary tools for a perfect tile skirting job as shown on drawing or as required by the Engineer.

All defects in the work shall be repaired by the Contractor as directed by the Engineer on his own expense.

The Contractor shall provide water drains in bathrooms and balconies.

The Contractor shall provide and install factory mounted dry pressed flat tile complying with the following requirements or as directed by the Engineer.

Unglazed vitrified ceramic tile.

Nominal dimensions:	20x20 cm, 30x30cm, 40x40cm. Dimensions could be larger, in bigger rooms, according to the Engineer approval. (Not larger than 90cm).
Nominal thickness:	10 mm or as specified and required
Breaking strength:	1500N – 3000N
Stress group:	U4 – EN 102Plain with square edges
Resistance to deep abrasion:	< 300 mm^3 - EN 186-1
Wearing surface:	Smooth
Face:	Plain with square edge
Water absorption:	E < 3% - Group B1
Density by Volume:	2.4 g/cm3
Quality:	First choice
Color of the tile:	Selected by the Engineer
Type of installation:	Laid with enriched cement sand mortar (1:3) over floor creed (measured separately)
Joints:	1- 1.5mm (to the approval of the Engineer)
Grout:	Colored grout and joint filler as per Manufacturer's recommendation and to the approval of the Engineer. Waterproofing additives shall be added to the grout for the damp areas.

Installation and grouting as per BSCP 202 Tile flooring and BS 6431 Ceramic wall and floor tiles.

All Corners vertical and horizontal in damp areas, shall receive adequate silicone filler to the approval of the Engineer.

3 MARBLE TILES

Marble could be used, where applicable, for floor and skirtings.

The Contractor shall provide and install factory polished flat tile complying with the following requirements:

Description:	Light Ivory Color Marble Tiles.
Nominal dimensions thickness:	40x40x2cm thick
Country of origin:	Lebanon
Absorption by weight:	0.16% - C97
Density:	2688Kg/m^3 - C97
Compressive strength:	1209 kg/cm^2 - C170
Abrasion resistance:	4.72mm
Thermal expansion coefficient:	0.0072 mm/m°C
Ultimate tensile strength:	174 kgs/cm2
Face:	Plain
Type of installation (measured separately):	Laid with enriched cement sand mortar (1:3) over floor screed
Joints:	1 - 1.5 mm (to the approval of the Engineer)
Grout:	Colored grout and joint filler as per Manufacturer's recommendation and to the approval of the Engineer. Waterproofing additives shall be added to the grout for the damp areas.
Grinding and polishing:	Grinding and polishing shall be done after laying and grouting the marble tiles of a minimum of 21 days. The crystallisation of the finished surface shall be refused.

A setting tile layout drawing shall be submitted to the Engineer for approval before starting any tiling works.

The edges of the marble tile shall be sound without any chipping or fractures subject to the refusal of the tiling works.

4 LIGHT IVORY COLOR MARBLE TREADS AND RISERS

The Contractor shall provide and install factory manufactured precast flat treads, risers and thresholds with the following requirements:

Source of fabrication: One source for each type in conformity with BS 4131 or equivalent.

Description: Light Ivory Color marble treads, risers and thresholds shall each be in one piece. In general, they shall be identical in specification to perlato tiles as specified previously, but the thickness shall be 3 cm, with sizes as specified on the drawings and approved by the Engineer. Reinforcement shall be provided if required by the Engineer according to the length of tread, riser or threshold.

The treads shall incorporate a cast iron nosing, minimum 30 x30 x 3 mm with tangs cast in. The nosing shall incorporate a non-slip textured top surface, all to the approval of the Engineer. The treads shall incorporate handling/anti-crack reinforcement. Treads and risers shall be solidly bedded on cement and sand, all in accordance with the approval of the Engineer.

The height of the risers shall be in conformity with the detail drawings and checked on site prior to any ordering of material.

The Contractor is bound to produce to the Engineer approval, detailed drawings for the as-built staircase with the treads and risers to be ordered.

5 GLAZED CERAMIC WALL TILES (CHINESE PORCELAIN TILES)

Wall tiles shall be of the best quality with sizes as shown on the drawings.

Before installation, samples shall be provided to the Engineer for approval.

Walls shall be cladded with Chinese porcelain tiles as shown on the drawing with the consideration of tile and tile bed thickness.

The bed beneath the tiles shall be white grout and shall meet the requirement of the manufacture that provides the tiles. These tiles shall conform to the following requirements:

- Porosity: less than 10%
- Breaking resistance: Under pressure of (7±0.5) Kg/cm², it shall not show any breaking signs. Under pressure of (10±0.5) Kg/cm².
- Width tolerance: ±0.3 mm.
- Thickness tolerance: ±0.4 mm.

Maximum offset in the surface: Less than ±0.7 mm.

Tiles shall be saturated with water before being laid and shall be laid with narrow joints without sticking to each other. Wall joints shall be aligned with floor joints. 24 hours after laying the tiles, the joints shall be covered with white cement grout.

The Contractor shall, at the end of the works, clean the tiles with spirits of salt.

If a ruler of 2 m. long is used, no unevenness shall be allowed of more than 2 mm.

If a plumb is used, no unevenness shall be allowed for more than 5 mm. of the total height.

6. NATURAL STONE CLADDING

6.1. STONE MATERIAL

Stone shall be natural from the best local quarries and approved by the Engineer.

It shall meet the following requirements:

- No hollow sounding.
- Free of defects.
- Weighs at least 2.5
- Breaking strength greater than 600 Kg/cm²

Stone shall not be affected by ice or any porosity signs and shall be free of any scratches, cracks or defects to give an even appearance The size of stones shall follow the requirements of the drawings.

The Contractor shall submit samples for the Engineer's approval and shall stay at site during the whole period of cladding.

In general, two types of natural stones shall be used for wall cladding:

- Natural Bump Stone – Rough Finish: Minimum thickness 4cm at the cut edge. The location shall be as shown on drawings or as directed by the Engineer. In general, the area covered by this stone type shall be not less than 80 % of the cladding area)
- Bush Hammered natural Stone – Sooth finish – Rough Finish: Minimum thickness 2cm. The location shall be as shown on drawings or as directed by the Engineer

6.2. MORTAR

Mortar for laying the stone and pointing shall be composed of 600 kg CPA 250/315 cement for 1 cubic meter of sand. The thickness is 3 cm of the mortar after stone has been laid. The quantity of water to be used in the preparation of mortar shall be only that required to produce a mixture sufficiently workable for the purpose intended. Mortar shall be used as soon as possible after mixing and shall show no visible signs of setting prior to use. Retempering of mortar will not be permitted.

The materials of mortars shall be measured out in their correct proportions and shall first be thoroughly mixed together in a dry state by turning them over upon a clean wooden stage until they are of a homogeneous appearance in consistency and color. Clean water shall then be added while the mixture is being turned over until it is thoroughly mixed.

SECTION 08300
SUSPENDED CEILINGS

1 GENERAL

1.1 Work Included

This section deals with technical requirements for the design, manufacture, delivery, off-loading and erection of the miscellaneous suspended ceilings.

Works include but are not limited to the followings:

- supply and installation of metal framework and attachments for mounting to the load-bearing structure,
- supply and installation of tiles, strips, ceiling panels or other components of the ceiling itself including hooking, mounting and connection systems (anchors, clips, slides, slide rails, etc.),
- finishing (lacquered metal profiles for edge covering, etc.) and all related works,
- protection of metal structures in the conditions defined in the present document,

1.2 Related Work

Works shall be executed in accordance with all other sections of Tender Documents, particularly with:

A. Section VII – A. General requirements;

B. Section 01010 - Corrosion protection;

C. Section 03300 – Concrete;

D. Section 01020 – Basic mechanical requirements;

1.3 Description

Suspended ceilings shall be installed in halls, offices, sanitaries and in all pedagogical and living facilities. They won't be allowed neither in process areas nor in all exploitation and technical rooms in contact with water or condensation.

The false ceilings proposed may be of concealed framework, aluminium ceiling panels, coated gypsum board or laminated wood.

The selected materials must be suitable for the type of premises in which they are to be installed (humidity, excess pressure, etc.).

1.4 Quality Assurance

1.4.1 Codes and Standards

Application of ceiling units shall be done in strict accordance with the manufacturer's specifications unless otherwise approved.

1.4.2 Design Criteria

The false ceiling primary framework (where applicable) must be able to support the weight of lighting fixtures.

The secondary framework must be able to support the other technical equipment whether flush-mounted or suspended (fire detection system, sound installation, etc.).

All necessary measures must be taken to prevent problems due to condensation.

In damp premises, the false ceiling framework must be connected to the building earthing system.

1.4.3 Shop Tests and Inspection

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:

A. The seals and the embedded parts shall be presented separately and unpainted for checking.

B. The surface appearance of embedded parts shall be examined and their dimensions checked.

C. All dimensions shall be checked.

1.5 Submittals

The Contractor shall carry out studies, calculations, diagrams, construction and detail drawings of structures. These drawings shall show clearly the sizes, methods of fixing, jointing and anchorages to be used in the process.

1.6 Dimension Tolerances

1. Ceiling panels and metal strips: 1/500 of the span between supports, with upper limit at 5 mm.
2. Fibreboard panels: 1/300 of the span in the case of visible framework.
3. Unevenness tolerances: 3/10 mm for chamfered components.
4. Gap between visible framework and panels: 1 mm maximum.
5. General flatness of suspended ceilings made of panels, of fibreboard and aluminium: deflection or camber less than 3 mm under 1.20 m rule for ceilings smaller than 4 m² and under 2.00 m rule for ceilings larger than 4 m².

2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1 Manufacturing

The Contractor shall choose framework and materials in relation to regulatory requirements, in particular those concerning fire and panic risks, and contractual requirements in terms of resistance, absence of uplift, suitability in relation to humidity conditions of premises and soundproofing,

Timber framework shall be treated with insecticide using products with the CTB.F label that do not stain the ceilings,

2.2 Spare Parts and Special Tools

The contractor shall specify and supply the special tools required for equipment maintenance.

3 EXECUTION

3.1 Inspection Before Erection

The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.

3.2 General

Space to receive ceiling units shall be satisfactorily closed and protected against the weather two months before beginning and during work.

Temperature shall be maintained at 10°C or above while system is being installed.

Space to receive ceiling units shall be dry and with no more dampening materials to be installed.

All cuts and recesses for incorporating components supplied by the different trades (electricity, heating, ventilation, etc.) are under Contractor's responsibility. This work must be carried out on the basis of instructions supplied by the different companies during the preparation of slab layout drawings, to be submitted, prior to any production, for the approval of the Owner or his representative,

The Contractor shall create grooves, notches and holes in the walls and load-bearing framework for securing, anchoring or putting in place of suspended ceiling components. He shall also fill in any such grooves, notches and holes that remain visible after installation work,

The Contractor is responsible for installation and removal of any scaffolding needed for performance of the works, irrespective of the height of the structures,

Tarpaulins and protection of structures of other trades, that might be damaged during the performance of the works described in the present chapter, shall be set.

Perfect coordination shall be assured:

- for the fitting of ducts, piping and wiring and installation of apparatus (light fittings, outlets, fire detectors, sound installation etc.),
- for connection of the structures (stability, etc.),
- for painting and covering works.

3.3 Ceiling Suspension System

The false ceilings will be either suspended to the underside of the floors, of poured reinforced concrete on standard formwork or COFRASTRA type metal formwork (or similar), or on prestressed permanent shuttering concrete slab, under the framework comprised of beams and prestressed purlins.

In these last three cases, drilling and power-activated fastening is prohibited.

False ceiling framework must be installed using clamps around the purlins.

The provision of any special parts for securing the components is included in the supply.

SECTION 09500
FENCING

1 GENERAL

1.1 Work Included

This section covers miscellaneous works which are necessary for the completion of the Works and which are shown on the Drawings or which may be required by the Engineer.

1.2 Related Works

Works shall be executed in accordance with all other sections of Tender Documents.

1.3 Description

Are described in this Section the followings:

- Fencing

2 PRODUCTS

2.1 Fencing

The new fencing shall be wire mesh type as following:

The fence generally consists of IPE 100 steel posts (60mmx60mmx6mm) and 3mm dia. Galvanized/vinyl coated wire mesh around 1.5m high. The upper part of the posts shall be inclined 45 degrees outside with three rows of barbed wire 100mm apart. The posts shall be fixed to a reinforced concrete stem-wall by steel plate (200mm x 200mm x 15mm) and 4 nos. of J bolts 12mm in diameter each.

The average space between two posts shall be maximum 3m.

Fence total height shall be at least 1.95 m from the ground-covering-gravel, and aspect shall be validated by the Engineer after presentation of at least 3 samples.

The fence shall incorporate a steel gate, have the similar wire mash form, but fixed to two concrete columns. as shown and specified in the drawings and including a pedestrian door access.

3 EXECUTION

3.1 Fencing

Fencing shall be installed as per Manufacturer requirements and other relevant sections/drawings of this Tender Document, especially section 03300 - Concrete.

SECTION VII – EMPLOYER'S REQUIREMENTS

PART F: GENERAL TECHNICAL SPECIFICATIONS: MECHANICAL AND ELECTRICAL WORKS

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SECTION VII – F: TECHNICAL SPECIFICATIONS: MECHANICAL AND ELECTRICAL WORKS

SECTION 01020

BASIC MECHANICAL REQUIREMENTS

1 GENERAL

1.1 Work Included

This section of the specifications covers the general requirements applicable to all mechanical equipment to be supplied, unless different requirements are specified in the subsequent sections.

In case of conflict between the requirements of this general specification and those of the specific equipment specifications, the latter shall have precedence.

1.2 Quality Assurance

1.2.1 General

The equipment shall be manufactured in accordance with established practice. All the components shall be finished as required by their importance, position and destination. The manufacture shall be sound, without any faults likely to impair their ability to fulfil their purpose:

1. All equipment shall be designed in compliance with up-to-date practice;
2. Equipment design shall take into account control and maintenance operations as well as operating incidents;
3. The general aesthetic appearance shall be studied and shall blend in with the overall architecture of the structures.

1.2.2 Materials

1.2.2.1 General

Materials shall be new and of first-class quality.

Rolled and cast steel shall be of good quality and free from blow or shrinkage holes, porosity, cracks or other defects.

Cast iron is not acceptable for any tap, valve bodies or components subject to internal pressure.

The Contractor shall indicate in the calculation notes the quality of the materials with reference to International (ISO) or American (ASTM,..) or European (DIN or BS or NF,..) or Japanese (JIS) or equivalent standards, and their mechanical and chemical properties. Such information shall be given for all materials used in the construction of the main items of equipment before procurement commences.

Materials shall comply with the list below or be similar according to other acceptable standards:

1.2.2.2 Main Types of Materials

European standards or equivalent as below:

- Structural steel:.....EN 10025
  .....EN 10137
- Non alloy high strength steel:.....EN 10083
- Low alloy high strength steel: .....EN 10083

- Corrosion resisting steel: .....EN 10088
- Iron casting: .....EN 1561
- Alloy steel casting: ..... A 32054
- Steel bolts and nuts: ..... EN ISO 3506
  .....EN 20898.
- Corrosion resisting steel bolts and nuts: ..... EN ISO 3506
  .....EN 20898
  .....EN 10088.
- Steel pipes and fittings: ..... EN ISO 559
  ..... EN ISO 2604
  ..... EN ISO 4200
  ..... EN ISO 5252
- Bronze: .....E 44158
  ..... EN ISO 5755

Alternative materials shall be submitted to the Engineer's approval.

1.2.2.3 TESTING OF MATERIALS

All materials shall be tested in compliance with the relevant European or ASTM or similar acceptable standards. In particular:

- CCH 70-2 for the castings.
- CS GFF 3-72 or equivalent for the forgings.
- ASTM for steel plates pipes and laminated products.

1.2.2.4 Cast Steels and Castings

Before any part is cast, drawings of the major items showing the proposed locations of the samples which are to be sent for mechanical and chemical tests, shall be submitted for the Engineer's approval.

Blow holes and all other such defects which become apparent after cleaning or machining must be ground to sound metal before any rectification is undertaken.

Castings shall not be twisted nor show any other form of distortion, nor increase in their dimensions (above that already taken into account) which could cause interference with other parts. The metal structure of the castings shall be homogeneous and free of all non-metallic impurities.

If, at any point of a critical section, the casting exhibits any unacceptably high concentration of impurities or alloying elements, the part will be rejected.

Major castings shall be submitted to ultrasonic inspection or radiographic examination where the results of ultrasonic testing are doubtful or not practical. These tests shall be complemented by magnetic particle inspection or dye penetration test.

The Manufacturer shall establish a quality sheet for each major casting.

Castings exhibiting defects of severity levels 4 or 5 in category A through E in accordance with ASTM E 186 will be rejected.

Casting defects shall only be corrected by welders of the highest quality using the best welding techniques. All castings requiring rectification during any stage of the manufacturing process after they have been initially annealed, shall, unless otherwise indicated, be re-annealed.

Casting defects which require correction by welding shall be reported to the Engineer and shown on a drawing or by means of photographs. Approval shall be obtained from the Engineer before the corrective work is carried out.

1.2.3 Welding

1.2.3.1 Qualification

For pressure tanks and hydraulic cylinders, the qualification of welding procedures and welders shall be in accordance with the requirements of ASME, Boiler and Pressure Vessel Code, Section IX.

For other components the qualification of welding procedures and welders shall conform either to ASME, Section VIII, Division 1, Section IX or the Standard Qualification Procedure of the American Welding Society at the Contractor's option.

Other welding standards and procedures translated in English will be accepted only to the extent that they conform to the above accepted codes and specifications. Exceptions to these standards and procedures will be made only where approved in writing by the Engineer.

1.2.3.2 Welding

Welding shall be performed by the electric arc method. Electroslag welding will also be permitted.

All welds shall be made continuous. Welds on gate or other submerged equipment shall be watertight. Butt welds shall be full penetration welds welded from both sides.

Contractor will provide sufficient temporary bracing to control distortion during welding.

1.2.3.3 Welded Structures - Stress Relieving

Components, mainly those made up of large cross section members, welded to the middle of the section or having large weld beads, shall be given stress relieving heat treatment. This treatment shall apply in particular to:

a) Components which will have to be precision machined;
b) Structures exposed to buckling forces;
c) High carbon steel components;
d) Equipment submitted to internal or external pressure.

This list is given for guidance purposes and shall not relieve the Contractor of his responsibility.

1.2.3.4 Weld Finish

Welds shall display good appearance and shall be suitable for painting. Structural welds shall be ground.

Final machining of welded parts shall be performed after welding and if applicable after stress relieving.

1.2.3.5 Weld Testing

Non-destructive tests shall be in accordance with EN 10246.

For each item of equipment, the Contractor shall propose for the Engineer's approval the type and extent of non-destructive weld testing.

a) The Contractor will proceed with examination of at least 20% of the weld lengths completed by each welder.
   Butt welds will be given radiographic test. The Contractor shall propose the best suited type of test for welds other than butt welds.
b) Welds on pressure tanks and servomotors shall be fully tested.
c) In addition to the requirements A, all main welds shall be fully tested by ultrasonic and magnetic particle or dye penetrant tests complemented by radiographic examination where interpretation by other methods is unclear.

d) Minor welds shall be spot tested.
Examination of welds and acceptance or rejection will comply EN 10246.

1.2.3.6 Weld Repairs

Defective welds shall be repaired by removing the weld material from the defective zone until sound metal is reached. The weld shall then be remade. Repaired areas shall be subjected to a new radiographic examination.

If a radiograph reveals an unacceptable zone, an extra radiograph will be taken on each side of the said zone.

If the new radiographs do not indicate any defect that would require rejection of the weld, only the zone covered by the first radiograph will be repaired. If further unacceptable defects are indicated, a complete radiographic examination shall be carried out.

Any given weld area cannot be repaired more than twice.

1.2.3.7 Electrodes

Electrodes must be stored under the conditions specified by the supplier and used within a maximum time of six months as from their date of manufacture. If this duration is to be exceeded, the Engineer will have the right to require the execution of new electrode quality tests.

For electrodes particularly sensitive to humidity (especially basic electrodes), if they have not been stored in a dry condition in perfectly watertight wrappings, they shall be baked before use, according to the supplier's instructions.

1.2.4 General Provisions for Equipment Design

1.2.4.1 Wear

The Contractor shall be considered to be fully aware of the properties of the water used and the atmospheric conditions and, accordingly, under normal operating conditions, the equipment supplied shall not be subject to any abnormal wear.

All parts of equipment subject to water induced wear shall be provided with interchangeable parts that can be easily refilled by welding or replaced. These interchangeable parts shall be made from a material selected in relation to the intended use and the probable wear of the part. The Contractor shall indicate the composition and properties of the materials used on the basis of analyses carried out by the suppliers. He shall specify the type of electrode suitable for refilling by welding if this process is used. The design of bearings shall be such that no friction induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

The design of bearings shall be such that no friction-induced corrosion shall occur. The absence of any such wear will be checked at the end of the period of guarantee during equipment inspections.

All electrical equipment parts liable to normal or accidental wear shall be designed to resist the action of atmospheric agents and climatic conditions.

1.2.4.2 NOISE

The project is designed to limit noise as much as possible.

- In technical equipment rooms:

The sound power radiated by all the equipment during maximum operation must not exceed the following values (per octave band):

Frequency in Hz	25	250	500	1000	2000	4000	8000
Log in dBA	82	82	78	75	72	69	65

Overall value: 80 dBA.

- Generally speaking, the levels must not be in excess of 80 dBA at 3 m of each equipment.

1.2.4.3 Vibrations

During normal operation, the vibration r.m.s velocity, measured on the unit bearing supports, shall not exceed 4.5 mm/s. The vibration r.m.s speed is defined in standard VDI 2056.

The various maneuvers of the gate and valve equipment shall be carried out under all possible loads without any harmful vibration or excessive noise occurring.

The knife edge of each gate shall be streamlined and designed to prevent vibrations regardless of their degree of opening.

1.2.4.4 Access And Protection Equipment

Provision shall be made for access to and protection of the equipment so as to ensure safety during operation, maintenance and inspection. All rotating parts such as wheels, shafts, transmission belts and all live electrical equipment shall be suitably protected by metal housings. Such provision is to be made at the locations and in the positions approved by the Engineer.

The Contractor shall supply all catwalks, platforms, ladders, railings, trap doors, manholes, and access hatches tied up to the equipment and necessary for proper operation, maintenance and personal safety.

The Contractor shall submit to the Engineer for approval his proposals for the passage of gutters and for the locations of trap doors, platforms, access doors and ladders, together will all dimensions of spaces to be allowed for the passage of equipment.

1.2.4.5 Arrangement Of Operating Equipment

No manual controls for lifting or pulling maneuvers shall require a force of more than 200 Newton, and no manual controls involving the operation of a wheel crank shall require a force of more than 100 Newton.

Wheel cranks shall be located approximately 1 m above floors or platforms. The controls and measuring instruments shall be readily accessible, without any need for special equipment, and clearly marked with identification numbers.

1.2.4.6 Handling and Dismantling

All equipment shall be installed by using the normal operational ways. No acceptance will be done by the Engineer for installations using exceptional means.

Equipment shall be designed for easy dismantling and maintenance operations. Dismantling and maintenance of electrical equipment shall be possible without stopping or disturbing other equipment in its vicinity.

All equipment or parts of equipment designed to be dismantled and handled shall be provided with:

a) Lifting rings, lugs, hoisting collars;
b) Slings, chassis and special handling apparatus such as: grappling beams, monorails, trolleys, jacks, pulley and ratchet systems, etc.;
c) Special jack screws appropriately located and in sufficient numbers for the dismantling of the relevant parts.

For heavy components, the Contractor shall provide special facilities for lifting each component. The Contractor shall also provide the necessary lifting gear for this equipment such as manually or electrically operated monorail hoists, hydraulic jacks, etc.

The above equipment shall be included in the Contractor's supply and shall be retained by the Employer.

1.2.4.7 Interchangeability

All machined parts included in winches, pumps, gears, etc. and all moving parts in general, shall be interchangeable and capable of being easily erected on a similar type of apparatus, except for standardized equipment.

For all the contract equipment, all electrical or hydraulic apparatus, equipment, instruments and accessories (for air, water or oil circuits) of the same rating and designed to perform the same functions or operate under comparable conditions within a given operating range, shall be identical and interchangeable.

If certain modifications are made to the equipment during manufacture or erection, these modifications must be submitted for the Engineer's prior approval and shall be made to all the equipment of the same type.

At his own expense, the Contractor shall keep for a minimum period of ten years all the manufacturing drawings and all design data likely to be of use in making repairs or possible replacement of components of the equipment.

1.2.4.8 Temperature Rise

The maximum temperature of metal parts of bearings and thrust bearings and that of lubricating oil shall be:

- Metal parts: 80°C.
- Lubricating oil: 60°C.

These temperatures when reached shall trigger an alarm in the control room.

The temperatures hereunder shall trigger emergency shut down of the unit:

- Metal parts: 85°C.
- Lubricating oil: 65°C.

The temperature rise of metal parts of bearings, thrust bearings, reduction gears and other mechanical systems shall not exceed 40°C above the ambient temperature or, in the case of outdoor equipment, 40°C above the outdoor temperature in the shade.

The rise in temperature of lubricating oil, measured around the metal parts quoted above shall not be more than 30°C above the ambient temperature or, in the case of outdoor equipment, 30°C above the outdoor temperature in the shade.

1.2.4.9 Lubrication

Lubrication devices and systems are included in the supply. Lubricating bearing materials shall be submitted to the Engineer's approval.

Self-lubricating systems will be provided wherever possible and are mandatory for submerged or temporarily submerged equipment unless the loads applied prevent their use.

Self-lubricating systems for submerged or partially submerged parts shall be provided with protective seals.

The systems proposed shall be of proved and referenced design. References shall be supplied by the Contractor.

1.2.4.10 Operating Speeds and Loads

The operating speeds defined in the technical specifications shall be guaranteed under normal operating conditions and under all loads within a 5% tolerance band.

The maximum operating loads specified by the Contractor shall be considered as guaranteed.

1.2.4.11 Nameplates

All equipment shall have a permanent engraved metal nameplate secured by screws clearly showing all pertinent information regarding the equipment, in the English language, including at least the following:

a) Manufacturer's name and address,
b) Name, type, serial number and other equipment identification data,
c) Rating and other design data,
d) Date of manufacture.

1.2.5 Design of Miscellaneous Detail Equipment

1.2.5.1 Auxiliary Pipework and Pressure Tanks

Pipework shall be supplied with the corresponding flanges, nuts and bolts, threaded unions, isolating valves (cast iron excluded), supports and anchoring.

Pipework design shall comply with the following values:

a) Slope greater than 1% for the drainage lines.
b) Water and oil flow velocities not to exceed 4 m/s.

Pipework embedded in concrete shall be systematically tested under pressure before concreting. All pipe end seals or blank flanges necessary for these tests shall be provided by the Contractor. No pipework made of malleable materials, such as lead, copper, etc. shall be embedded in concrete.

Pipe internal and external protection shall be by hot galvanizing. Subsequently, after each welding operation, the galvanization is to be repaired by wire brushing and application of a compatible enriched zinc paint.

Galvanization is not required for oil piping. The external surface of the oil pipes shall be protected by painting as per Section 01010 - Corrosion protection.

All flanges and couplings shall be suitably placed to facilitate dismantling of corresponding equipment and appliances, with a sufficient number of isolation valves to avoid loss of fluid when partial dismantling work is carried out.

All pipes shall be installed in order to be easily dismantled for maintenance.

Flanges and couplings shall be suitably placed to facilitate dismantling. These flanges and couplings shall be indicated on drawings, with the dimensions.

Tests:

c) Pressure tanks and pipework shall be tested at a pressure at least 50% greater than the maximum operating pressure.
d) Free-surface tanks and basins shall be tested for watertightness before painting. They shall be filled with water for 24 hours. The watertightness of the welds shall be tested with compressed air and a soapy solution, or by any other method approved by the Engineer.

1.2.5.2 Tightness Of Water and Oil Circuits

All bearings, oil, water and air pipes, pumps and other associated apparatus shall be perfectly tight. No water, air, oil or grease leak shall take place. Any condensation and possible leakage shall be collected and drained off. The design shall be such that no oil splashes or vapor will reach electrical equipment.

1.2.5.3 Couplings

Couplings between electric drive motors and the various types of driven equipment shall be of the semi-elastic type and shall have a service factor of 1.5.

1.2.5.4 Bolts, Nuts, Screws

All bolts, nuts and screws in contact with water or in a damp atmosphere shall be made of corrosion-resisting materials. A pre plating treatment of 10-12 microns shall be applied to High Resistance Bolts subject to continuous or intermittent immersion in water. Particular care shall be taken to avoid contact corrosion. Threads under vibration shall be especially treated with special resins.

All shims to be used shall be protected from corrosion by cadmium plating, sherardization or by any other process approved by the Engineer.

1.2.5.5 Anchoring

For all anchoring, use of "fish-tail" systems is strictly prohibited.

1.2.5.6 Seals For Gates and Valves

The Contractor shall pay particular attention to seal joints, especially in corners, so that a continuous line of contact is maintained. The seal corner joints shall be cast in one piece and vulcanized or glued to the lateral and frontal seals.

The seal backing plate holding bolts shall be of stainless steel. The bolt holes in the gate skin plate, the seals themselves and the backing plate shall be drilled in the workshop. If the gates are to be shipped dismantled, the seals shall be removed and packed separately.

All gate and valve seals shall be free of any defect. The seals must be made of synthetic rubber, non-reactive to contact with grease or hydrocarbons. The seals shall be designed to make field adjustment and maintenance easy.

The seals of the gates shall comply with the requirements given hereunder without any special devices having to be used. Local leaks and average leaks per linear meter of seal shall not exceed the following values:

a) Local leaks: 0.25 liters per second;
b) Average leaks: 0.10 liters per second per meter.

Valves seals shall be completely watertight.

1.2.5.7 Holes For Concreting and Grouting

Holes of at least 200 mm in diameter shall be provided in the horizontal part or bottom of linings between stiffeners and welded seams, in order to concrete a surface area of approximately one square meter. Hole covers shall also be provided.

All holes in the hydraulic conduits for concreting and grouting purposes shall be fitted with screwed plugs and then seal welded in place, rendering the part watertight, and shall be carefully ground flush.

1.2.6 Embedded Parts and Linings

1.2.6.1 General

All embedded parts and linings shall be designed to withstand both the hydrostatic pressure at the point of installation as well as the grouting pressure.

The stiffeners of the vertical embedded parts shall be designed so as not to hinder the concreting carried out on site.

Sufficient quantities of tie bars and adjusting rods shall be provided. The latter shall be attached to the steel plates embedded in the primary concrete. The steel plates will be designed solely for adjusting the position of the corresponding embedded parts and shall under no circumstances be subjected to high loads nor shall they replace the anchoring embedded in the primary or secondary concrete. If, according to the design of the embedded parts, the Contractor supplies and installs steel sections to be embedded in the secondary concrete for adjustment of the embedded parts, then such sections shall not be less than 40 mm from the concrete surface facing.

All surfaces having contact with the seals as well as the sliding surfaces shall be made of corrosion resisting materials.

All corrosion resisting parts, whether intended for the sill, the side walls, etc. installed in the sluiceway shall be perfectly flush with the sluice profile. Any unevenness or level differences will be rejected.

For normal stiffening of vertical or horizontal embedded parts (except in the case of self-resisting embedded parts), the end of the stiffeners shall not, insofar as possible, cut the concrete in the form of "L" or "T" sections.

1.2.6.2 Fixed Parts for Gates

In order to facilitate the introduction of gates into their slots, the top of the embedded parts making up the gate slot shall have a lead in section which diverges 30° from the vertical. The frontal embedded parts shall comprise an upper section to ensure good contact with the transverse seals when the gate arrives in the closed position.

1.2.6.3 Linings

The welds joining the steel plates together and joining the steel plates to the corrosion resisting steel sliding surfaces located in the sluices shall be very carefully ground flush and refilled if necessary, so that there are no cracks, protrusions nor misalignments.

All welds shall be continuous, solid and watertight. They shall all be subjected to crack detection tests:

a) Crack detection tests along 100% of the joints between liners;
b) Crack detection tests for 20% of all other welds.

No indentations or protrusions over 1.5 mm in depth or height, or with a slope greater than 3° shall be permitted on any part of the sluices surface.

1.2.6.4 Loading Conditions

1.2.6.4.1 Water loads

Water loads shall be considered as follows:

- 10 kN/m³ for clean water
- 11 kN/m³ for sewage water

1.2.6.4.2 Allowance shall be made for the following loads:

a) Weights, buoyancy, hydrodynamic loads and loads generated by gates, valves and penstocks movements (such as friction forces);
b) Loads generated by the guiding systems;
c) Loads generated by the obstruction of trash racks.

1.2.6.4.3 Earthquakes:

The Contractor shall design structures according to local seismic rules and data, submitted to the approval of the Engineer.

1.2.6.4.4 Hydraulic transient

The pressure surges generated by the closure of valves and gates shall be taken into account. The maximum amplitude of the pressure surge to be taken into account is specified in the corresponding section.

1.2.6.4.5 Load combination

Each of the following conditions shall be considered for normal loading of gates.

a) Gate or valve closed:

The effect of the following loads shall be combined:

- ~ Hydrostatic load corresponding to the water level acting on the gate or valve, no water on the opposite side;
- ~ Dead weight of the gate and hoist connecting rods bearing on the gate, reaction forces acting on the supports;

b) Gate or valve being closed or opened at any point of travel:

The effects of the following loads shall be taken into account:

- ~ Weight of the gate (included weight of any other gate mounted equipment, ballast…);
- ~ Weight of hoist connecting rods bearing on the gate;
- ~ Hydrostatic load corresponding to the piezometric level acting on both sides of the gate or valve;
- ~ Hydrodynamic loads corresponding to flow conditions;
- ~ Rated hoist pull, rated thrust (if any) or required control load acting on the gate;
- ~ All load components caused by seal friction, guide loading, friction of pistons and pins of cylinders after a long inactive period and other effects;
- ~ Additional friction and/or blocking forces in the guiding devices and against the seals.

1.2.6.5 Allowable Stresses

Gate: unless otherwise specifically indicated for a type of structure or equipment, allowance shall be made for the following values: DIN standard 19704. Chapter 7 or equivalent.

1.2.6.6 Buckling Of Cylindrical Parts, Conduits, Penstocks

The factor of safety against buckling for cylindrical parts shall be as specified in the CECT design code.

1.2.6.7 Loads On Supports, Anchors and Concrete

The Contractor shall furnish the values of the loads applied by the equipment on the supports and anchors.

The allowable compression stress applied on the concrete shall meet DIN 19704/4114 standards or equivalent.

1.2.6.8 Permissible Tolerances on Gates and Fittings

(Any tolerances specified in the subsequent sections have priority over these tolerances).

Tolerances shall be as follows:

1. For all stainless sealing strips: sills, lateral risers and frontal cross pieces: In the longitudinal and transverse directions:
   a) local flatness: ..... 0.5 mm over 100 mm
   b) general flatness: ..... 1 mm
   c) general straightness: ..... 1 mm
2. On the standard lining panels:

Along the height and width of the sluice:

a) local flatness: ..... 1.5 mm over 500 mm
b) general flatness: ..... 2 mm
c) general straightness: ..... 2 mm

Along the length of the lining panels:

a) general straightness:..... 2 mm

The general flatness condition shall apply to the lining panels after on-site welding, i.e. along the whole length of a given side wall.

Between the lateral stainless steel sealing strips:

1. Parallelism (between sealing strips): 2 mm.
2. Perpendicularity (of each sealing strip to the sill): 1 mm.

All tolerances shall allow a good operation of the equipment. All tolerances not in agreement with above specified values shall be submitted to the Engineer's approval.

SECTION VII – F: TECHNICAL SPECIFICATIONS: MECHANICAL AND ELECTRICAL WORKS

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SECTION VII – F: TECHNICAL SPECIFICATIONS: MECHANICAL AND ELECTRICAL WORKS

SECTION 01030

BASIC ELECTRICAL REQUIREMENTS

1 ELECTRICAL PLANT

1.1 Applicability

The following clauses specify the general requirements for the electrical equipment. General specification clauses shall apply except where specifically redefined elsewhere in the Specification.

1.2 Power Transformers General

1. Power transformers shall comply with IEC 76 unless otherwise specified. They shall be suitable for General use on a three-phase system.
2. The materials used and the method of construction shall be of the first-class quality and shall be such as to ensure optimum performance and uniform temperature throughout the transformer.
3. In the design of the transformer, special attention shall be paid to reduce noise level to a minimum.
4. Each transformer shall be provided with a main frame earthing terminal which shall be separate from the neutral terminal of a star connected winding.

Where the neutral of a star connected winding is to be separately connected to earth, an insulated neutral connection shall be brought out via a separate neutral chamber having provision for housing one or more current transformers for earth fault protection. A removable cover shall permit access to the current transformers and their secondary wiring.

5. Main cable terminations shall be provided to suit the type of cable used.

Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable and cores.

The boxes shall provide sufficient space for segregating the cores and maintaining the minimum insulation clearance and creepage distances applicable.

Cable boxes to accommodate low voltage (up to 1 000 volts) PVC or XLPE insulated cables shall be air insulated, designed to exclude direct ingress of moisture and dirt.

For voltages above 1 000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

6. Auxiliary wiring from current transformers, Buchholz relays, winding temperature indicators, pressure switches, etc., shall be marshalled to a separate termination chamber with separate access cover. The terminal boards or blocks shall be as specified for switchboard components. Removable, undrilled cable gland plates shall be provided.

1.3 Oil Filled Transformers

1. Oil filled transformers shall be suitable for indoor service and arranged for natural air cooling (Type ONAN) and shall comply with the specification for power transformers.
2. Constructional steelwork shall be shot blasted or chemically pickled internally and externally and shall be thoroughly descaled and degreased before being given the first coat of a comprehensive painting process which shall, for the interior, be of paint or varnish able to resist the action of oil. The exterior shall be primed with one coat of zinc-enriched paint followed by two undercoats of contrasting color followed by one top coat of durable, oil resisting and weather resisting paint.

3. Main connections shall be brought out through oil-tight bushings into their respective connecting chambers and shall be provided with disconnecting links to facilitate cable testing and complete removal of the connecting chamber from the transformer without the necessity of breaking the cable termination.
4. Each transformer shall be delivered filled with oil.
5. Temperature sensing devices shall operate a dial type indicator with a red line showing maximum permissible operating temperature. The indicator shall incorporate adjustable alarm and trip contacts to operate on excess temperatures.

Silica-gel breathers shall be fitted with indicators and shall be conveniently located for regular inspection and ease of silica-gel renewal.

Buchholz relays shall have their gas sampling cocks conveniently placed for operation from ground level.

1.4 Tap-Changers

Off-circuit tap-changers shall comply with IEC 76-4, unless otherwise specified.

Tapping on HV side (%) shall be: ± 2.5, ± 5.

Tap-changers shall be delivered filled with oil.

1.5 Diesel Generator Set

1.5.1 Scope

This chapter covers the requirements for the low voltage diesel generator sets.

1.5.2 Codes and Standards

The design, manufacturing, construction, installation, test and commissioning of diesel generator sets shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60034 Rotating electrical machines

IEC 60044 Instrument Transformers

IEC 60072 Dimensions and output series for rotating electrical machines

IEC 60085 Electrical insulation - thermal evaluation and designation

IEC 60255 Electrical relays

IEC 60269 Low-voltage fuses

IEC 60529 Degrees of protection provided by enclosures (IP Code)

IEC 60896 Stationary lead – acid batteries, ventilated types general requirements and methods of test

IEC 60947 Low-voltage switchgear and control gear

ISO 3046 Reciprocating internal combustion engines – Performance

ISO 8528 Reciprocating internal combustion engine driven alternating current generating sets

As far as the power supply authority or permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

1.5.3 Environmental Conditions

The diesel generator sets shall be designed and constructed for continuous operation at full load under the local climatic and environmental conditions.

The diesel generator sets shall be installed inside specific container, which will be equipped with ventilation.

1.5.4 Fuel Requirements

The diesel generator shall be capable of operating as specified with diesel fuel that is in compliance with the applicable local requirements.

1.5.5 General Requirements

1.5.5.1 Components and Equipment

The Contractor has to take care that all components and equipment are selected considering easy maintenance, simple and quick diagnosis and long maintenance intervals.

All components and equipment shall be designed for continuous duty at rated load and under the given climatic conditions. Standard industrial high-performance systems and components of supplier's standard lists shall be used as far as possible. Components and equipment of same kind and type shall be selected for equivalent functions. The interchangeability must be guaranteed.

1.5.5.2 Aging

All components, equipment and installations shall receive the respective tagging plates, labels, etc., which have to be of extremely durable material resistant against the environmental conditions. Tagging plates or labels on fronts of enclosures shall be fixed with screws.

1.5.5.3 Unit And Scales

The metric system on basis of SI-units shall be used for all scales and indications.

1.5.6 Equipment Characteristics

1.5.6.1 General

The diesel generator sets shall consist of the following main parts:

- Diesel engine.
- Generator.
- Starter equipment.
- Fuel system.
- Lubrication system.
- Air intake and exhaust system.
- Control and monitoring system.

Diesel engine and generator shall be placed on a common base frame and connected with a dry flexible coupling.

The diesel generator sets shall be provided in a manner such that 10 sec after initiation of start the full load can be taken over.

1.5.6.2 Engine

1.5.6.2.1 Motor

The engine shall be equipped with a water cooled, turbo-charged, four-stroke diesel motor suitable for indoor installation.

1.5.6.2.2 Cooling

The engine shall be provided with a closed loop, jacket cooling water system. The system shall be sized for continuous maximum load with ambient temperature.

The engine shall be furnished with a thermostatic control valve in the jacket cooling system to maintain a constant jacket coolant temperature to the engine.

The cooling water heat exchanger shall be of the finned radiator type equipped with fan. The radiator shall be mounted on the engine skid. The fan shall be preferably driven from the engine. A separate electrical motor for fan driving will be also accepted.

For the engine a standstill heating system shall be provided.

1.5.6.2.3 Lubrication system

The engine and if necessary, the generator shall be fully pressure-lubricated. The main oil pump shall be gear-driven from the main shaft.

1.5.6.2.4 Starting system

For engine start an electrical starting system with starter motor, 24 V lead-acid battery set and battery charger shall be provided.

The capacity of the battery shall allow six consecutive starts of the engine within 10 minutes. After the mentioned number of starts the battery shall have 50% capacity.

The charger shall be sized for recharging of the batteries within 8 hours.

1.5.6.3 Generator

For the low voltage diesel generator unit a 3 phase, air cooled generator with shaft driven ventilator shall be provided.

The generator shall tolerate the sudden application or rejection of 50% of its rated power without unacceptably high voltage fluctuations in excess of 5%.

The generator winding shall be according to insulation class F; the utilization shall not exceed the figures for class B insulation. Insulation class H, utilized according to F will also be accepted.

The stator windings shall be equipped with six Pt 100 temperature sensors, which shall be wired to a common terminal box.

For the generator a brushless rotating exciter and a solid-state type voltage regulator shall be provided. The voltage regulator shall be with automatic and manual control to within a deviation of 0.5% from no-load to full load at rated frequency.

The excitation and de-excitation control equipment shall be combined with the voltage regulation equipment and shall be placed inside of generator unit control panel.

The generator shall be sized to withstand short circuit currents (three phase, line to earth, two lines to earth) for one second.

The generator shall be equipped with a standstill heater with automatically initiation when the generator unit is being out of service.

1.5.6.4 Base Frame

The diesel engine, the generator and the cooler will be placed on a common welded base frame. To minimize vibrations the engine, the base frame shall be fixed via rubber-metal elements or equal shock absorbing materials on the foundation.

1.5.6.5 Pipes And Cabling on The Diesel Generator Set

External pipe connections (air intake, exhaust, fuel, etc.) to the vibrating parts of the unit shall be made with compensator tubes, flexible connections or hoses.

Cables and electrical connections shall be mechanically protected and resistant against oil, heat and vibration.

As far as practicable, the power and instrumentation cables shall be terminated in junction boxes, located at one edge of the skid. For power and instrumentation cables separate junction boxes shall be used.

1.5.6.6 Intake Air System

The engine shall be fitted with an outdoor installed oil wetted foam air filter, preferably. The filter and the air intake duct shall be sized to suit engine requirements at 100% of rated full load.

The filter shall be equipped with louvers, which shall automatically open during start of generator unit. The louvers shall be controlled via the diesel generator set control panel and shall operate with 24 Vdc.

1.5.6.7 Exhaust System

Temperature-resistant materials shall be used for the exhaust piping and the required expansion bellows. Exhaust silencers shall be galvanized. Expansion joints in the exhaust pipe shall be made of metal.

The exhaust pipe and the silencer are to be heat insulated in the room and in the wall bushing. Silencer to achieve the required noise dampening to at least 85 dB(A) shall be provided.

1.5.6.8 Fuel System

For the diesel generator set a seven-day tank shall be provided, which will be installed near the generator. The volume of the tank shall be suitable for seven-day full load operation of the diesel generator set. Fuel tanks, incorporated in the base frame are not allowed.

The fuel tank shall be fitted with visual level indicator and level alarm devices for remote indication.

The suction of the extraction line shall be arranged at least 10 cm above the fuel tank bottom or otherwise suitable positioned in order not to take in sludge or water which may have accumulated. Furthermore, a flame trap shall protect the ventilation openings of the tank.

The fuel tank shall be equipped with all necessary devices (pumps, pipes, filters etc.) to allow the filling from an external fuel system.

1.5.6.9 Engine Gauge Panel

On the diesel generator set a local panel shall be installed which is vibration isolated from the engine.

The following instruments shall be provided:

- Lube oil pressure.
- Engine cooling water temperature.
- Lube oil temperature.
- Speed.
- Running hours.

If the control cabinet will be installed within the diesel generator set room the placement of the above-mentioned instruments on the door of this cabinet is also allowed.

1.5.6.10 Control And Monitoring System

1.5.6.10.1 General

The control and monitoring system shall be realized by means of highly available and highly reliable programmable logic controller (PLC), preferably.

The system shall protect control, monitoring and emergency operation of the diesel generator set during start-up, operation, load change and normal shutdown.

The protective functions shall also be active during all operation modes.

The control functions shall essentially be required for start-up and normal shutdown, and the regulating functions shall mainly be needed for unit operation during the normal operating phase.

The unit regulating functions shall be designed for the adjustment of all key operating data which may be kept constant for any desired length of time. Load changes shall be effected safely.

For switch over to diesel generator set supply and back to network supply the LV switchgear will be equipped with an "automatic change over device" (by switchgear manufacturer). Via this device the normal network will be monitored to initiate the start and stop of the diesel generator set.

The control and monitoring system shall be provided with a serial interface to the station control system. Emergency stop functions and the connection to the automatic change over device of LV switchgear shall be hardwired.

1.5.6.10.2 Emergency stop

The unit shall be provided with an automatic stop via fail-safe controls. All process criteria and measures initiating emergency stop shall be transferred to the station control system.

The diesel generator set must be stopped with blocking at least in case of the following conditions:

- Emergency stop push button.
- Overspeed.
- Low lube oil pressure.

And all other abnormal conditions which can be dangerous for the diesel generator unit.

The overspeed sensing element and emergency stop mechanism shall be independent from the regulator governor apparatus and governor drive. The overspeed trip shall act on the injection pump, preferably.

1.5.6.10.3 Control cabinet

The equipment for the control and monitoring system and the necessary auxiliaries shall be placed inside of a metal enclosed, self-standing cabinet.

The control cabinet shall be equipped with the following main parts:

- Circuit breaker for generator main circuit.
- Sub distribution panel.
- Battery charger.
- Control unit.
- Measuring instruments.
- Display or indicator panel.
- Switches, push buttons.

The cabinet shall also include the facilities for automatic synchronizing and manual/automatic voltage regulation.

The supply voltage for sub-distribution panel, which shall feed standstill heater, battery charger and may be air conditioning for control cabinet shall be 230/400 Vac, 50 Hz. The voltage level for control, protection and monitoring shall be 24Vdc, fed from the internal charger/battery.

On the hinged front door of the control cabinet the following devices shall be installed:

1. Instruments:
   i) Operating hour meter.
   ii) Lube oil pressure.

iii) Generator voltage (with selector switch).

iv) Battery voltage.

v) Current (all three phases).

vi) Frequency.

vii) Active power.

2. Switches, push buttons:

i) Selector switch for operating modes (off-manual-test-automatic).

ii) Manual/automatic voltage regulation selector switch.

iii) Push buttons for voltage regulation.

iv) Push button for initiation of automatic synchronization.

v) Push buttons for diesel generator set unit ON/OFF.

vi) Emergency stop push button with latching function.

vii) Push button for lamp test.

3. Display or indicator panel with the following indications:

i) Fuel tank empty (20% level).

ii) Lube oil low pressure alarm.

iii) Lube oil high temperature alarm.

iv) Generator windings over temperature alarm.

v) Cooling water high temperature.

vi) High speed alarm.

vii) Generator overload alarm.

viii) Generator synchronized to network.

For all indications, measuring and alarms the respective sensor shall be installed on the diesel generator set and its auxiliaries.

To the station control system, the following signals shall be transferred:

- Fuel tank empty (20% level).
- Fuel tank full.
- Diesel generator set in operation.
- Control voltage fault.
- Emergency stop (diesel generator blocked).
- Summary alarm.

From/to automatic change over device in the LV switchgear the following signals shall be transferred:

1. From automatic change over device to diesel generator set:

i) Diesel generator set “Start”

ii) Diesel generator set “Stop”

iii) Reference voltage for synchronization.

2. From diesel generator set to automatic change over device:

i) Diesel generator set not available.

ii) Emergency stop.

iii) Diesel generator set ready for taking over of load.

iv) Diesel generator set synchronized to network.

v) Switching over to generator supply / network supply.

For all remote signals potential free contacts or the respective coupling relays shall be provided and shall be wired to a separate terminal stripe.

The main circuit shall be equipped with protection relays or releasers for generator windings high temperature.

The protection relays shall be of the latest state-of-the-art technology, electronic type, programmable with display.

1.5.6.11 Modes of Operation

For the diesel generator unit, the following operation modes shall be provided:

1. Off

The control logic is blocked; all signals will be indicated. A switching into this position during running engine will initiate a stop command.

2. Manual

All functions (start/stop, voltage regulations, automatic synchronization, etc) shall be initiated from the control cabinet. In case of network power failure an automatic switch over to emergency supply shall not be executed.

3. Test

The diesel generator unit start and synchronize automatically and initiate a signal “Switching over to generator supply” to the changeover device. After switching the selector switch to manual or automatic diesel generator unit synchronized and initiate the signal “Switching over to network supply” to the changeover device. After this the engine stops with a respective time delay. If during test run the normal network fails the diesel generator unit shall switch over automatically to emergency supply (via start signal from automatic change over device).

4. Automatic

In case of network interrupt all functions (start, synchronizing, etc.) shall be carried out automatically. After return of normal network, the synchronization and stop shall also be carried out automatically, but with manual initiation from remote or from control cabinet.

During automatic mode no other orders can be given from the control panel, the initiation of stop can only be given if the normal network is available.

The selector switch for operation modes shall be lockable.

1.5.6.12 Wiring

The wires shall be selected according to load, insulation level, function and operating requirements. The wires shall be adequately rated and equipped with fuses/circuit breakers of adequate size.

The wiring shall be carried out solid and safe against damages. Wires shall be bundled and fixed. The wiring shall be laid inside of wiring channels, preferably. If wiring channels will be used, they must be from halogen-free type and a spare of 20 % shall be foreseen.

Terminal strips shall have 10 % spare terminals. If wires with different potential will be terminated on one terminal strip the respective terminals shall be separated by means of isolating plates. The termination of multiple stranded wires has to be carried out by means of multiple core cable ends.

Terminals shall be marked durable and easily readable, corresponding to the drawings. Wires shall be marked on the termination of each wire with the number of the corresponding connection point.

1.5.6.13 Painting

All components and devices shall have a resistant, long-term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

An additional painting at location of installation is not allowed.

1.5.6.14 Cables and Cable Laying

For connection between different parts of the diesel generator set or one distribution board copper cables with PVC insulation shall be used.

All cables shall be selected according to load, insulation level, function and operating requirements. The minimum cross section for power and signal cables shall be according to specification “Basic electrical requirements”. Signal cables shall be provided with copper screen.

1.6 Low Voltage Variable Frequency Drive Unit

1.6.1 General

1.6.1.1 Description

Provide complete IGBT (Insulated Gate Bipolar Transistors) type variable frequency drive (VFD) units and appurtenances including drive reactors, transformer, DC chokes, harmonic filters, enclosures, and certain auxiliary items in one integral line-up, as indicated and as specified, to provide a complete operating system. Provide all drive components specified housed within one enclosure.

The Contractor shall provide only one VFD drive manufacturer for all drives under this Contract. The Contractor to coordinate the VFD units with the driven equipment manufacturers.

VFD units shall be manufacturer's standard technology and in production for no less than 5 years.

Provide control system operation, input and control signals, status signals and devices as specified herein and as indicated.

Provide Underwriter's Laboratories listed drive or equivalent IEC/BS Standards.

Coordinate VFD input harmonic filter with results of final harmonics study outlined in Paragraph 2.2.

VFD units rated at 75 HP and larger shall be 18 pulses type. VFD units smaller than 75 HP shall be 6 pulses type. Drives up to 20 HP shall be provided with 5% impedance line reactor. Drives larger than 20 HP and less than 75 HP shall be provided with integral input harmonic filter pre-wired in the same enclosure.

Provide each VFD unit as one complete line-up, complete with main circuit breaker, inverter section, phases shifting transformer, power converter, harmonic filter, output filter, and control circuit as indicated. Floor mounted VFD units provided shall be secured to a concrete pad.

1.6.1.2 References

As specified herein or equivalent IEC or BS Standards:

1. Underwriter's Laboratories Inc. (UL):
   i) UL-508 Electrical Industrial Control Equipment.
2. National Electrical Manufacturers Association (NEMA).
3. National Fire Protection Association (NFPA):
   i) NFPA-70 National Electric Code.

4. Equivalent British/European codes and standards may be used; however, the equivalency shall be demonstrated and submitted by the Contractor and approved by the CM/CS.

1.6.1.3 Submittals

Shop Drawings: Submit the following in accordance as specified herein.

1. Shop Drawings: Provide a complete list of equipment components, and materials, including manufacturer's descriptive and technical literature, and catalog cuts. Provide complete wiring, system interconnection and schematic diagrams for the equipment and controls furnished including external interlocked and controlled components, equipment layout, time versus current curves for protective devices and any other details required to demonstrate that the system and the required external controls have been coordinated and will function as specified and indicated.
   i) Provide data to verify that drives can be used for motor lead lengths up to 100 feet without output filters. Include information from the VFD manufacturer or output filter manufacturer stating that the motor terminal voltage limitations as defined by NEMA Standard MG-1 are met. For VFDs located more than a cable length of 100 feet from the motor load provide output filter at VFD.
   ii) Provide enclosure drawings and details showing all dimensions and construction details.
2. Submit a statement from each driven equipment manufacturer indicating that the VFD drive submitted is compatible with driven equipment and is rated for the specified application.
3. Harmonic Analyses Report: Provide harmonic analysis report as outlined in Paragraph 2.2.
4. Provide installation and anchoring details to meet earthquake requirements as specified and indicated on the structural drawings.
5. Submit manufacturer’s printed installation instructions.
6. Spare Parts Data: Submit a list of spare parts.
7. Operating and Maintenance Instruction Manuals:
   i) Operating instruction manuals outlining step-by-step procedures required for system startup and operation.
   ii) Manufacturer's name, model number, service manual parts list.
   iii) Brief description of equipment and basic operating features.
   iv) Maintenance instruction manual outlining maintenance procedures.
   v) Troubleshooting guide listing possible reasons for breakdown(s) and repair(s).
   vi) Point-to-point connection wiring diagram for the system.
8. Performance Test Reports: Upon completion of installed system, submit in booklet form all shop and field tests performed to prove compliance with specified performance criteria.

1.6.2 Products

1.6.2.1 Manufacturers

Manufacturer shall have five years, all within the last 10 years, commercial experience in the manufacture, operation and servicing of equipment of type, size, quality, performance, and reliability equal to that specified.

1.6.2.2 Harmonic Analysis

The VFD manufacturer shall provide a detailed harmonic analysis as described under this section.

The VFD system shall be provided such that there is less than 5% voltage total harmonic distortion at the point of common coupling (PCC).

Obtain the available short circuit current at PCC from the electrical short circuit study. Provide this information to the VFD manufacturer to perform the harmonic study.

Provide the standby generator unit data to the VFD manufacturer.

The harmonic analysis performed shall be based on the following cases:

1. Case 1 – Point of common coupling 380 Vac main bus supplied by utility transformer.
2. Case 2 – Point of common coupling 380 Vac main bus supplied by the standby diesel generator.

The study shall include an explanation of all assumptions, sources of data, methodologies and formulas used in the study and a summary of the study results.

Based on the harmonic study results, supply the VFD units with any additional filtering equipment required to meet the harmonic requirements specified herein.

1.6.2.3 Provisions

1.6.2.3.1 Service conditions

Service conditions shall be as follows:

1. Ambient Temperature Range: 0 deg. C to 40 deg. C.
2. Operational Humidity: Up to 90 percent non-condensing.
3. Environment: As indicated on enclosure schedule.
4. Altitude: Below 1,000m above sea level.
5. Input Power:
   i) Nominal voltage - 380 volts (plus 10 percent or minus 10 percent), 3-phases, 3 wires
   ii) Nominal Frequency - 50 Hertz (plus or minus 2 Hz.)

1.6.2.3.2 Drive systems

a) General

Furnish solid state variable frequency, microprocessor type with Pulse Width Modulated (PWM) output wave form converter. The VFD shall employ a full wave rectifier, a dc bus choke, dc bus capacitors and Libya Infrastructure Master Spec 16260-7 20-Nov-08 Insulated Gate Bipolar Transistors (IGBT) as the output switching device to convert nominal 380 volts, 3 phases, 50 Hertz, 3 wires input power into adjustable-frequency 3 wires system at 0 to 380 volts, 3 phases, 0 to 50 Hertz output power.

Motor control circuits shall be wired in accordance with the requirements specified herein and as indicated.

The Contractor shall be responsible for the successful compatibility and operation of the entire drive and control system serving the motor and driven equipment. This includes the responsibility for obtaining all loads, torque, speed and performance requirements from the pump and motor manufacturers and integrating these into a variable frequency drive system that fulfills the requirements of this Specification.

Provide constant torque drives or variable torque drives based on the type of the driven equipment load.

Provide VFD control so that there is accurate zero to full load torque control at low frequencies, including zero speed, with torque repeatability accuracy of 2% or better and torque response time less than 20 ms.

Provide on drive thermal magnetic type, 380 volts circuit breaker to be used as main disconnecting device and fixed diode input rectifier for a constant power factor.

For 75 HP units and larger, provide VFD with three phases, PWM rectifier section, 18-pulses, or higher full wave diode bridge. Provide phases shifting transformer within enclosure at input bridge to provide appropriate phases shift.

1. The transformer shall provide for the cancellation of the positive and negative sequence harmonic currents at the primary connection.
2. The transformer shall reduce voltage and current distortion on the primary side and voltage distortion on the secondary side.
3. The VFD shall be optimized for harmonic rich and high neutral current environment.
4. Harmonic cancellation shall be by electromagnetic means only, capacitors or electronics shall not be used.
5. Provide a primary to secondary phase shift by use of multiple secondaries.

RMS harmonic output of the drive not to provide more than 5 percent increase in motor heating over similar operation of the motor with zero harmonics in the current.

The unit shall withstand drive output terminal line-to-line and line-to ground short circuits without component failure during start-up and during operation. Drive to safely shutdown until short is cleared.

Provide drives with NEMA-1 gasketed type cabinet for VFD units located in indoor air-conditioned spaces. Provide NEMA-4X enclosures for VFD units located outdoor or in no air-conditioned spaces. NEMA-4X VFD enclosures shall be designed with ventilation/air conditioning system to dissipate the heat generated inside the enclosure.

Provide drive output such that the motors have a base rating voltage less than or equal to 600 volts and that the peak instantaneous voltage shall be limited to 1600 volts or less, with a voltage rise time greater than or equal to 0.1 micro-seconds per NEMA Standard MG-1, Part 31.40.4.2.

The drive unit shall be of modular design to provide for ease and speed of maintenance.

Control circuits shall be isolated from power circuits. Unit to accept a 4-20 mA dc speed control signal from an isolated, ungrounded transmitter with unit in remote mode and from local door-mounted manual speed potentiometer or micro-processor type keypad with unit in local mode. The input 4-20 mA signal to be optically isolated from the drive run control circuit. Furnish door-mounted switch on the enclosure for local/remote mode. Manual speed potentiometer or keypad controls to have adjustable minimum speed setting of 10 to 80% of full speed and maximum speed setting of 50 to 100% of full speed. The total speed setting to follow a linear time ramp, adjustable from 1-300 seconds for acceleration and deceleration control. Provide output 4-20mA signal for VFD speed statues.

Harmonic filters shall be provided with contactors and controlled by the VFD to remove them from the line when the drive is not operating. Contactors shall be provided with spare contacts for remote alarm and to energize status lamp at VFD enclosure.

VFD shall be capable of full rated output when powered by incoming voltage with Total Harmonic Distortion (THD) in excess of 10%.

Furnish series choke and capacitors on dc bus to reduce ripple in rectifier output and to reduce harmonic distortion reflected into incoming power feeders.

Size enclosure to dissipate heat generated by VFD within limits of specified service conditions. Provide integral fans or cooling systems. VFD enclosures to have keypad controls located on exterior of enclosure. Provide visual alarm indicator on cabinet door.

Provide oversized cable lugs for incoming and outgoing cables. Cable lugs size shall be per cables as indicated.

b) Performance characteristics

Continuous current rating (amps): Minimum of 110 percent of motor rated full load amps, continuous.

Acceleration time to top speed, 1-60 seconds, adjustable.

Deceleration time from top speed, 1-60 seconds, adjustable.

Frequency stability: +/- 0.5% (at 25 degrees C, +/- 10 degrees C) after reaching operating temperature.

Output voltage: Proportional to frequency with low-speed boost.

Combined drive/and filtering efficiency, defined as VFD output KW divided by VFD input KW, shall meet the following requirements at the specified operating points:

1. 96 percent minimum at 50 Hz VFD output and 100 percent load.
2. 92 percent minimum at 40 Hz VFD output and 60 percent load.

VFD fundamental power factor shall be 0.95 or higher at all speeds and loads.

The VFD shall be capable of sustaining continued operation with a 30% dip in nominal line voltage.

Losses to be utilized in drive system efficiency calculation shall include the input isolation transformer, harmonic filter and power factor correction if applicable. Auxiliary controls such as internal VFD control boards and cooling fans shall be included in all loss calculations.

c) Drive protection

1. General:
   i) Fault detection and trip circuits shall protect VFD and connected motor against line voltage transients, single-phase, power line over-voltage and under-voltage, output over-voltage and overcurrent, and VFD over-temperature. The VFD shall employ three (3) current limit circuits to provide trip free operation. The slow current regulation limit circuit shall be adjustable to 125% of the VFD's variable torque current rating. The rapid current regulation limit shall be adjustable to 170% of the VFD's variable torque current rating. The current switch off limit shall be fixed at 225% of the VFD's full load current rating.
2. Internal Protection: Provide circuitry as follows:
   i) Current limiting, fast acting, semiconductor input fuses for protection of internal power semiconductors.
   ii) Instantaneous output over-current trip max. - 200 percent.
   iii) DC bus and control circuit transformer fusing.
   iv) Grounded control chassis.
   v) Under and over voltage trip, 3 phases.
   vi) Motor overload protection, with solid state relays.
   vii) Main circuit breaker, with door interlocked handle. Provide means to allow entry into panel by authorized personnel. Circuit breaker to be rated 65,000 AIC.
   viii) Fault reset push button.
   ix) Line to ground faults.
   x) Input metal oxide varistor and input line reactor for transient protection.
   xi) VFD over-temperature.
3. Troubleshooting: Provide diagnostic aids to indicate cause of fault; used to assist in troubleshooting circuit problems. Isolated Form C contacts for remote indication of alarms to include the following:

i) Over/under voltage indication.

ii) Over-current trip indication.

iii) DC bus charged indication.

iv) Fault detection indication.

v) Recycle start indication (to indicate that the unit tried to pick up load for three previous tries and failed).

4. Provide power loss ride through capability which will allow the logic to maintain control due to load inertia without faulting.

1.6.2.3.3 Auxiliary systems

Provide variable frequency drive unit with appropriate power circuitry and auxiliary contacts, etc. for energizing and controlling the variable frequency drive as indicated.

1.6.2.3.4 Control Features

Provide VFD control circuit as indicated on Contract Electrical Drawings.

Accept a grounded, isolated, 4-20 mA input remote speed control signal from an external device.

Provide a 4-20 mA output signal proportioned to VFD output frequency for remote speed indication.

Jog permissive input. When activated along with remote run contact, VFD will run at a pre-set speed.

1.6.2.3.5 Devices

Provide operating, monitoring or alarm indicating devices, door mounted, as indicated on Contract Electrical Drawings and as follows:

1. System speed control selector switch (LOCAL/AUTO) (When in LOCAL position, speed controlled by manual speed potentiometer).
2. Manual speed potentiometer or keypad controls to set speed in manual mode.
3. Speed indicating meter in percent speed to indicate speed of the powered motor.
4. Control relays as indicated.
5. Alarm and status lights. Provide LED cluster type.

Tie all instrument transformer outputs to motor protection relay.

1.6.2.4 Shop Testing

Provide a factory performance test for each variable frequency drive unit. The test to consist of simulating the expected load to be driven. The drive to operate the actual motor load through the expected speed ranges. Test length to be two hours.

Provide a factory burn-in test and a control and alarm test on each drive unit by simulating each control signal and each alarm function to verify proper and correct drive unit action.

Provide prototype factory test data for a similar size and type VFD unit for short circuit testing. Data to verify that each drive can be started into a line-to-line fault and line-toground fault on the drive terminals. Each drive can be operating at full load and be subjected to a line-to-line fault and line-to-ground fault on the drive terminals. All phases (A, B & C) to be included in test data.

Provide certified documentation of all tests performed.

Provide above stated tests in addition to routine factory tests.

1.6.2.5 Spare Parts

Provide three spares pilot lamps, power fuses, and control fuses of each type and size installed.

Provide one keypad for every size VFD, of the same model.

1.6.3 Execution

1.6.3.1 Inspection

Examine VFD location for preparation in accordance with manufacturers written instructions. Check conduits and raceway location for connection to units.

Visually inspect delivered unit(s) and accessories for conformance with specification and drawings.

Verify availability of appropriate pacing signal and program motor protection relay settings.

1.6.3.2 Installation

The VFDs shall be installed as indicated and in accordance with the manufacturer's installation instructions.

Factory-trained service technician, other than sales representatives, shall supervise field installation, inspect, make final adjustments and operational checks, make functional checks of spare parts, and prepare a final report for record purposes. Adjust control and instrument equipment until this equipment has been field tested.

1.6.3.3 Field Testing

Perform testing checkout, and start-up for variable frequency drive equipment under technical direction of manufacturer's service technician.

Coordinate all testing with electrical testing performed under Section 16998.

Field Tests:

1. Test each drive over the total speed range that it will be required to operate through for the load being driven for two hours. Determine for each drive, motor, and load combination the following at minimum speed, maximum speed, and at 1/3 and 2/3 points between the minimum and maximum speeds:
   i) Input power (kW), voltage, current and RMS power factor on the line side of the drive isolation device.
   ii) Output to the driven load in kilowatts.
   iii) For each drive, measure the harmonic voltage distortion and harmonic current distortion for each harmonic at the main distribution bus for maximum and minimum load conditions.
   iv) Measure the total harmonic voltage distortion and total harmonic current distortion at PCC, while all drive loads are running, for Case 1 and Case 2 as described under Paragraph 2.2. The test results shall confirm the harmonic study results and have to shall prove that harmonic distortion limits specified in Paragraph 2.2 have been met. If testing results are not within the specified limits, provide any additional necessary filtering equipment to meet the harmonic distortion limits specified.
2. Test each drive by using the actual control signal for remote and local operation.
3. Test each driver alarm functions.
4. Perform all tests in the presence of the Owner's representative.
5. Perform the above test in addition to the manufacturer's normal field tests and driven equipment testing.

Submit final test report with summary comparing field test data with harmonic analysis design calculated values for each drive.

1.7 Motor Starter Equipment

1.7.1 General

1.7.1.1 Quality Assurance

1.7.1.1.1 Codes and Standards

The design, manufacturing, construction, installation, test and commissioning of motor starter equipment shall be in accordance with the following codes and standards, at least. The latest revision of the publication referred to shall apply.

IEC 60038	Standard voltages
IEC 60051	Direct acting indicating analogue electrical – ` measuring instruments and their accessories
IEC 60071	Insulation co-ordination
IEC 60085	Electrical insulation - thermal evaluation and designation
IEC 60255	Electrical relays
IEC 60529	Degrees of protection provided by enclosures (IP-Code)
IEC 60664	Insulation co-ordination for equipment within low voltage systems

As far as the power supply authority and permits of other authorities require additional codes and standards, respectively impose additional requirements, these are also part of the contract.

1.7.1.2 General Requirements

1.7.1.2.1 Components and equipment

The Contractor has to take care, that all components and equipment are selected considering easy maintenance, simple and quick diagnosis and long maintenance intervals.

Standard industrial high-performance systems and components of supplier's standard lists shall be used as far as possible. Components and equipment of same kind and type shall be selected for equivalent functions. The interchangeability must be guaranteed.

1.7.1.2.2 Tagging

All components, equipment and installations shall receive the respective tagging plates, labels, etc., which have to be of extremely durable material resistant against the environmental conditions. Tagging plates or labels on fronts of enclosures shall be fixed with screws.

1.7.1.2.3 Unit and Scales

The metric system on basis of SI-units shall be used for all scales and indications.

1.7.1.2.4 Wiring

The wires shall be selected according to load, insulation level, function and operating requirements. The wires shall be adequately rated and equipped with fuses / circuit breakers of adequate size.

The wiring shall be carried out solid and safe against damages. Wires shall be bundled and fixed. The wiring shall be laid inside of wiring channels, preferably. If wiring channels will be used, they must be from halogen-free type and a spare of 20 % shall be foreseen.

All circuits and auxiliary contacts including not used contacts for disconnecting devices and relays shall be terminated on terminal strips. Terminal strips shall have 10 % spare terminals. If wires with different potential will be terminated on one terminal strip the respective terminals shall be separated

by means of isolating plates. The termination of multiple stranded wires has to be carried out by means of multiple core cable ends

Terminals shall be marked durable and easily readable, corresponding to the drawings. Wires shall be marked on the termination of each wire with the number of the corresponding connection point.

1.7.1.3 Design Requirements

1.7.1.3.1 General

The motor starter equipment shall start-up centrifugal pipeline pumps, which will be driven by low voltage asynchronous squirrel cage motors.

The motor starter equipment per motor consists of the following main parts:

1. Switchgear panel.
2. Soft starter for motor above 15 kW.
3. Control devices.

For each applicable pump motor unit, a separate starter shall be provided. All parts of the motor starter equipment for one motor shall be assembled to a common unit, exchangeable to each other for the same motor size.

1.7.1.3.2 Number of starts

The motors are designed to allow 4 starts successively from cold (max. Ambient temperature) or 3 starts successfully from hot service temperature without tripping of any protection device.

The starting time sequence is as follows:

1. (1) – (2) immediately.
2. (3) after 20 min.
3. (4) after further 20 min.

The motor starting equipment shall be designed and constructed to meet these requirements.

1.7.1.3.3 Starting procedure and limitations

For the motor starter equipment, the following starting procedure and limitations shall be valid:

1. The pump units will be started against fully closed or partial closed discharge valve, to be defined and coordinated with the pump manufacturer, depending on the final hydraulic requirements.
2. The motor start-up time shall be in the range of 20 seconds, but shall not exceed 30 seconds.
3. The motor start-up current shall be reduced to a value 3 times of the rated motor current.
4. The motor start-up torque shall not be lower than 0.3 of rated torque, the available torque difference between motor and driven pump shall not be lower than 15%.

The detailed pump and motor data and the actual curves shall be requested by the respective manufacturer.

1.7.1.3.4 Safety and interlocking devices

The motor starter equipment shall be equipped with safety and interlocking devices to prevent the following:

1. Closing of the circuit breakers in the service position, if they are not connected to the auxiliary circuit.
2. On-load operation of the isolation and earthing apparatus.
3. Access to the live parts.

1.7.2 Equipment Characteristics

1.7.2.1 Switchgear Panel

1.7.2.1.1 Mechanical requirements

a) General

The switchgear panels shall be air insulated, industrial type, metal-clad, factory assembled, type tested panels with self-standing cubicles and fix mounted switching devices. The cubicles shall only be accessible from the front.

The switchgear panels shall be suitable for indoor installation on cable cellar. The bottom shall be covered with galvanized steel sheets, which are to provide with holes for cable entry. The cable entries shall be designed in a manner such that a sealing after cable laying is possible without any problem. Further, each cover sheet shall be equipped with a grounding connection to the steel frame of cubicle.

The cubicles of the switchgear panels shall be equipped with hinged doors, which are able to swing out more than 90°.

All nuts for fixing of components shall be welded on the steel structure or threads will be cut in the steel structure. The use of loose nuts or self-cutting screws shall be avoided as far as possible. Screws, nuts and washers shall be galvanized or tinned.

b) Separation

The switchgear panel shall consist of cable termination cubicle(s), cubicles for bypass circuit breaker and star-point circuit breaker and the necessary bus bar, surge arrestors and cabling accessories. The circuit breakers may be installed in a common cubicle.

Each cubicle shall be equipped with a low voltage compartment, which is to placed in the upper part.

The different cubicles and the low voltage compartment shall be separated against each other by means of steel sheets. The isolation must be arc-proof.

All cubicles shall be equipped with separate pressure relief flaps. The pressure relief shall be carried out upwards.

c) Cable termination cubicle

The cable termination cubicles shall be supplied with suitable metal fastenings for connection of cable ends, or if necessary for bus bars. These fastenings shall be adapted, for each cubicle, to the number and type of cables or bus bars used.

The cable connecting and fastening bars shall be arranged in such a way to allow easy and safe connection of the number and type of cables and cores, designed for the particular switchgear panel.

Suitable cable fixing supports must be foreseen to secure the cable termination from any pull tension.

d) Low voltage compartment

All measurement instruments, push buttons, switches, indication and alarm lamps, etc. shall be mounted in the hinged front door and flexibly wired to the fixed part of the LV compartment. All relays, miniature circuit breakers, etc. Within the LV compartment shall be rail mounted.

The LV compartment shall have a layout and arrangement to allow easy access to all installed devices. On the door of the LV compartment a mimic diagram with position indication of switching devices shall be placed.

For the wiring from the low voltage compartment to the bottom a covered cable duct shall be foreseen.

1.7.2.1.2 Electrical requirements

a) Protection

The system of protection shall be selected and coordinated in line with the feeding switchgear data and the connected equipment requirements:

1. To guarantee personnel and plant safety.
2. To ensure a sufficient protection against damages of the equipment, which may arise from the internal and external short circuits as well as from possible atmospheric discharges.
3. To ensure as far as possible the continuity of operation for those parts not concerned by the fault. This will be achieved by selecting the setting in a way such that in case of a fault the closest protection device to the fault operates at first.

b) Bus bars

The bus bars shall be selected according to the electrical requirements and shall be of high-conductivity electrolytic copper.

The bus bar cross section shall be the same throughout the panel. It shall be adapted to service and installation conditions. Flexible joints shall be provided wherever necessary to avoid displacement due to expansion, or transmission of shocks and vibrations from the switchgear panel to the connections.

The utmost care shall be taken in the design of the position of the bus bar supports and the layouts of the connections taking into consideration the following:

1. Electro-dynamic stresses in disturbed conditions.
2. Resonance phenomena.
3. Isolation distances.
4. Temperature rises of conductors in these conditions.

c) Circuit Breakers

Circuit breakers shall be selected and equipped according to the requirements and will be fix mounted. Only one type of circuit breaker for each making and breaking capacity shall be used. The circuit breakers shall be three pole vacuum type.

The operation of circuit breakers shall be carried out via motor driven spring loaded buffers. In case of control voltage fault, the buffers shall be manually operable. The circuit breaker position shall be visible with closed front doors.

Each circuit breaker shall be equipped with the following devices:

1. Electrical control, closed contact operated, with anti-pumping device and electric resetting device.
2. Tripping coil with supervision relay.
3. Auxiliary spare contacts, at least 4 NO and 4 NC brought out to terminals.
4. Mechanical position indicators for switching position.
5. Indications for tripping and failure.
6. Operating push buttons for “On” and “Off” (easy operable from front door, “On” push button with lockable cover against male operation).
7. The necessary interlocks to prevent any fault operation.
8. The circuit breakers shall be suitable for short-time interrupt. For switching of the circuit breakers, the respective secondary releases and locking magnets shall be provided.

d) Auxiliary relays

Auxiliary relays shall be of plug-in type and shall be provided with test plugs for measurement on the front side. The test facilities shall be provided to permit testing without interruption of the entire installation and service (on service testing).

Auxiliary relays shall be of the electromechanical type. Auxiliary contacts shall be able to carry the maximum foreseen current. In any case their contact load shall be suitable for 230 Vac / 230VDC.

The relays shall be suitable for tropical climate and must be dust proof.

e) Overvoltage protection

The switchgear panels shall be designed and rated in a manner such that overvoltage caused by switching and flashes, do not impair the safety in operation of the units.

The circuit breakers shall be provided with surge arrestors, equipped with easy visible indicators for the healthiness of arrestors. The equipment inside of low voltage compartment shall be separately protected against overvoltage.

f) Control and monitoring

The control system shall be an integrated part of the switchgear panel and shall include the control and monitoring of the circuit breakers and the generator.

The control and monitoring shall be performed with an integrated PLC unit, which shall also control the motor feeder circuit breaker located in the generator switchgear.

The following signals shall be transferred from/to remote systems, at least:

1. Data exchange with the station/unit control system
   i) Commands
      ~ Motor “On”
      ~ Motor “Off”.
   ii) Signals
      ~ By-pass circuit breaker open
      ~ By-pass circuit breaker closed
      ~ Star-point circuit breaker open
      ~ Star-point circuit breaker closed
      ~ Summary alarm.
2. Data exchange with the motor feeder circuit breaker
   i) Commands
      ~ Circuit breaker “On”
      ~ Circuit breaker “Off”.
   ii) Signals
      ~ Circuit breaker open
      ~ Circuit breaker closed.

The data exchange with the station/unit control system shall be performed via serial link, the data exchange with the motor feeder circuit breaker will be carried out hardwired.

On the front door of one voltage compartment an indicator board shall be installed. All signals and alarms shall be indicated on this board.

g) Earthing

All exposed conductive parts likely to be accidentally charged shall be joined together by an earthing circuit. For this purpose, a minimum 100 mm² cross section bare copper earthing bus shall be installed.

This earthing bus shall be connected to the general grounding system by means of conventional cable connection terminals.

Within the panels, electric continuity shall be ensured by fastening screws and bolts. The opening type panels, assembled on hinges shall be bonded to the enclosure by a tinned copper braid, or hinges shall be certified for this purpose.

The following shall be also connected to the earthing circuit:

1. Secondary side of surge arrestors.
2. Leads of braid of the MV cables.
3. Operating handles, mounting plates, doors, etc.

In addition, two ends of the switchgear panel shall be terminated to the general grounding system by separate cables.

h) Control voltage

The control voltage supply will be carried out from a 230 Vac UPS. Each switchgear panel will be provided with one power supply, protected by means of a 16 A or 25 A miniature circuit breaker situated in the UPS distribution board. The sub-distribution of control voltage inside switchgear panel shall be carried out selective from the supply to the consumers. For motors of spring-loaded buffer and for control/monitoring different monitored miniature circuit breakers shall be used.

All other necessary control and signal voltage levels shall be generated inside the switchgear panel of motor starter.

i) Anti-condensation heaters

If necessary, the switchgear panels shall be equipped with anti-condensation heaters, which shall be fed from the 230 V, 50 Hz level. Each switchgear panel will be provided with one power supply, protected by means of a 16 A miniature circuit breaker situated in a LV distribution board.

The heaters shall be humidity or temperature controlled.

A failure of heaters shall be indicated on the local indicator boards.

j) Compartment lighting

The low voltage compartment of each cubicle shall be equipped with a lighting fixture, switched via door contact.

The lighting fixtures may be fed from the circuits of anti-condensation heaters.

1.7.2.2 Painting

All components and devices shall have a resistant, long-term stable, high quality painting. At least two layers have to be applied.

Damages, caused by transport, installation, cabling or commissioning shall be repaired in a way, that the original quality is restored.

An additional painting at location of installation is not allowed.

1.7.3 Execution

1.7.3.1 Installation

The delivery, installation and commissioning of the motor starter equipment shall include, but not limited to the following items:

1. Transport to location of installation (if necessary, storage), and the complete mounting.
2. Grounding and potential equalization for the cubicles, including connection with the next grounding bus bars.
3. Termination of all cables at the switchgear panels.
4. Commissioning of the functioning motor starter equipment, including voltage feeding of the bus bars and adjustment of all relays, protection devices, etc.
5. Briefing of the operation personnel in operation and maintenance during installation and commissioning phase and during a training on site.

1.7.3.2 Tests

1.7.3.2.1 Workshop tests

All components of the motor starter equipment shall be tested completely and detailed in manufacturers workshop. All tests required by the codes and standards as well as all manufactures tests have to be performed.

The test program for the work shop test has to be submitted prior to start of the tests in accordance with the Project Procedure Manual.

The following tests shall be carried out, at least:

1. Test of all functions.
2. Voltage withstand test (1)
3. Short circuit withstand test. (1)
4. Test of warming. (1)
5. Partial discharge measurements.
6. Check of degree of protection.
7. Check of protection against touching.
8. Power frequency voltage dry test, 1 minute.
9. Voltage test on auxiliary circuits, 1 minute 2 kV r.m.s.
10. Mechanical operation test on circuit breakers, including all adjacent equipment.
11. Operation test of the relays.
12. Test of auxiliary electrical devices.
13. Verification of wiring and terminal blocks.
14. Check of mechanical details.
15. Compliance with the specifications.

(1) only type test certificates necessary

Detailed test protocols of all tests performed have to be submitted prior to shipment.

1.7.3.2.2 Site tests

The site tests shall include the following steps:

1. Pre-commissioning (including "loop testing").
2. Commissioning and test on completion.
3. Performance test.

The workshop tests described in item except the power frequency voltage shall be repeated on site by the Contractor after erection and before connection to outside sources.

Special care shall be taken for setting of protection devices, relays and timers, setting must be done according to the approved start-up procedure, considering the data of the connected pump motor equipment and the feeding switchgear.

The aim of the tests is to ensure the proper function of the complete scope.

1.7.3.3 Documentation

Complete documentation shall be provided for the design, manufacturing, testing, commissioning, start-up, operation, maintenance and repair of the motor starter equipment and their components.

All documents shall be in English language.

The documentation of the motor starter equipment shall include the following documents and drawings (minimum requirements):

1. Technical data sheets.
2. Layout drawings for all devices, cubicles and enclosures.
3. Layout drawings for the whole motor starter equipment.
4. Single line diagrams.
5. Block diagrams.
6. Wiring diagrams.
7. Termination drawings.
8. Cable lists.
9. Spare parts list.
10. List of used devices with manufacturer.
11. Software and software description.
12. Operation and maintenance manual.
13. Reports of tests and commissioning with protocols.

The documents listed above shall be handed over for approval.

Special attention has to be given to the fact, that documentation must be submitted with sufficient time allocated for approval prior to manufacturing / assembly.

Documentation has to be prepared in accordance with the relevant ISO standards or in the absence of relevant details in those standards the DIN standards shall apply.

The final documentation shall be delivered on paper in sufficient number and with exception of the signed protocols in electronic form, also. The type of the electronic files shall be agreed with the Client.

1.7.3.4 Shipping

All equipment, material and spare parts shall be sufficient packaged. Each unit should be shipped as a common delivery. The material, especially loose parts and spare parts shall be clearly labelled according to the designation.

1.7.3.5 Spare Parts and Special Tools

The Contractor shall deliver all spare parts, which are necessary for commissioning and two years operation time (see "General Description of Project and Works").

Spare parts shall be available until ten years after commissioning.

All necessary special tools for operation and maintenance of the motor starter equipment shall be supplied for each location, at least consisting of:

1. One (1) set of all special tools required for operation and maintenance of switchgear panel and transformer.
2. One (1) set of circuit breaker tools and consumables.
3. Key set for cubicle doors and locks.
4. One (1) set of grounding equipment (ground rope and spider including fastening bolts and clamps, connections tongs etc.).
5. Software for the PLC.

For storage of the above-mentioned special tools per location a suitable cabinet, shelf or console shall be delivered.

1.8 Enclosures for Electrical Power Apparatus

1. Enclosures shall be fabricated from sheet Electrical Power steel of adequate thickness, suitably braced to form a rigid structure. The thickness of medium voltage boards and low voltage boards shall be 2 mm as a minimum. Exterior corners and edges shall be rounded to give a smooth overall appearance. Designs involving the use of externally visible assembly bolts and screws or rivets will not be acceptable.

   Enclosures mounted indoors and outdoors shall provide a degree of protection not less than lP54 to IEC 529 unless otherwise specified. The design of the enclosures shall be such as to ensure adequate ventilation and air circulation where required, without permitting the entry of vermin. Cable entries shall be closed and made vermin proof.

   Unless otherwise specified, enclosures shall be suitable for floor mounting.

   Where wall mounting enclosures are provided, the fixing details shall preferably comprise externally welded brackets but internal fixing arrangements will be acceptable provided that they prevent ingress of moisture. With either arrangement, the rear of the enclosure shall be not less than 10 mm from the wall.

   Lifting eyebolts shall be removed after installation and replaced by bolts.

2. Enclosures shall be pleasing in appearance, extensible, and symmetrically arranged as far as possible with projections kept to a minimum.

   Where two or more enclosures are fitted together, they shall form a flush fronted continuous suite of uniform height. Instruments, relays, and control devices shall not be mounted at a height greater than 2000 mm nor less than 300 mm from floor level.

   All individual components of equipment associated with a single item of plant shall be contained in a single enclosure. Where a number of plant items are in close proximity, the use of individual enclosures shall be avoided and composite enclosures shall be provided. Enclosures for multi-circuit switchboards shall be subdivided into single circuit compartments. Compartments shall be segregated by rigidly braced steel sheets and screens arranged so that, in the event of internal fault conditions, the fault damage is entirely confined to the faulted compartment.

3. The arrangement of the equipment within each enclosure shall be such that all normal maintenance can be carried out from the front through a hinged door. Composite enclosures shall be provided with a hinged access door for each compartment.

Enclosures containing switchgear and motor control gear shall be fitted with hinged front access doors to each compartment and, where rear access is available, bolted removable covers or hinged access doors at the rear.

Enclosures not requiring front access doors shall be fitted with hinged access doors at the rear.

Access doors shall have a flush appearance, and shall be fitted with locks or lockable handles. Front access doors shall be of rigid construction and free from distortion when equipment is mounted and supported on the door. Rear access doors shall have lift-off hinges arranged so that one shank engages before the other to permit ease of fitting. No instruments, relays or other equipment shall be mounted on rear access doors or removable covers.

4. Panels and cubicles shall be provided with earthing arrangements.

   On single cubicles, an earth stud shall be provided.

   Multi-panel switchboards or composite enclosures comprising a suite of individual sections or cubicles shall incorporate a continuous earth busbar.

   The earth busbar shall extend to all panel/cubicle sections. All panels and individual sections/cubicles shall be earthed by direct connections to the earthing busbar, which shall also include extensions and terminations for the earthing of the metal cladding and armoring of all incoming and outgoing power cables.

   On equipment having only front access, the main earth busbar shall be internally mounted but readily accessible.

   The earth busbar shall incorporate an external terminal assembly for the connection of a copper tape or cable from the station earthing system.

   A positive earthing conductor and termination shall be provided on all enclosure doors on which electrical equipment is mounted.

   The short-time rating of the earth busbar and connections shall be not less than that of the associated switchgear equipment, or the maximum through-fault current of the power source, and under fault conditions, the temperature rise of the busbar and connections shall not cause damage to the connections or any equipment to which they may be connected.

   For main distribution and plant control switchboards the cross-sectional area of the earth busbar and connections shall be not less than 25 x 3 mm.

   No earth terminal bolts or studs shall be less than 8 mm diameter.

5. Panels and cubicles shall be provided with anti-condensation heaters.

1.9 Busbar and Primary Connections

Busbars and primary connections shall be of electrolytic copper and shall be rated for continuous operation. The mechanical and dielectric strengths of busbar and connection insulators and supports shall be able to withstand the worst conditions of electrical surge which can occur on the installation, for any system fault condition internal and external to the switchboard.

Busbars and primary connections shall be housed in air-insulated enclosures which shall be arranged such that no direct access to or contact with live conductors is possible via slots or apertures.

All bars and contacts shall be coated with tin or any suitable paint resistant to hydrogen sulphide. Suitable baffles shall be provided to prevent the accidental entry of tools, etc., whilst maintenance work is being carried out in the vicinity of the chambers which shall be fitted with suitable warning labels.

The busbar shall be divided for both high voltage and medium voltage to provide maximum security and easy maintenance.

The busbars and primary connections shall have a short-time rating of not less than that of the associated switchgear.

All busbars, primary connections and power circuit conductors and wiring shall be color coded.

Phase sequence indicator shall be provided at the main feeders.

1.10 Cable Terminations and Cable Boxes

1. On multi-circuit switchboards and control panels, the power and control cables shall be glanded and terminated directly to the panel/circuit or compartment concerned.

   The cable boxes or gland plates for individual circuits shall be designed and located to permit the termination of the circuit cable without impeding access to the cable terminations of other circuits or sections of the switchboard.

   The use of common cable termination compartments on multi-circuit and low voltage switchboards will be approved only when the equipment location or mounting arrangement impedes direct access to individual circuits.

   Common cable termination compartments shall be complete with cable core terminations, with permanent wiring or cable riser connections to the individual circuits. Cable gland plates shall be arranged or split to permit the independent termination of individual circuit cables.

   Cable gland plates and/or supports for cable sealing boxes shall be provided and positioned to provide a minimum gland height of 250mm from the surrounding floor level.

2. Cable boxes to accommodate PVC or XLPE insulated cables for voltages up to 1000 volts shall be air insulated and designed to exclude direct ingress of moisture and dust.

   For voltages above 1000 volts, cable boxes to accommodate XLPE insulated cables shall be air insulated, totally enclosed and sealed to exclude moisture and dust.

   Cable termination methods shall be as specified.

   Cable boxes shall be fitted with cable glands and all fittings necessary to terminate the cable cores.

   The boxes shall provide sufficient space for segregating cores and maintaining the minimum insulation clearances and creepage distances applicable.

1.11 Circuit Breakers – General

1. Circuit breakers for indoor installation on systems having a nominal voltage up to 15kV shall be of the air, vacuum, or sulphur hexafluoride (SF6) filled type and, unless otherwise specified, shall be of the withdrawable pattern incorporated in metal-clad switchgear.

   Circuit breakers shall be capable of interrupting all faults up to their maximum rating without damage to equipment or danger to personnel.

   Test evidence of the normal current rating, and certification by an independent switchgear testing authority of the symmetrical breaking capacity of circuit breakers shall be submitted when required.

   Isolating facilities shall be provided for all circuit breakers. Means shall also be provided for testing the normal operation of the circuit breaker when in the fully isolated position.

2. Circuit breaker operating mechanisms shall be of the following types:

   Independent manual spring.

   Hand-charged spring with manual release.

   Motor-charged spring with electrical release.

   Direct current (dc) solenoid.

All operating mechanisms shall be trip-free and shall have mechanical "ON" and "OFF" indicators and a manual trip device fitted with locking facilities. Hand charged and motor charged spring mechanisms shall have "SPRINGS CHARGED" and "SPRINGS DISCHARGED" indicators.

Operating mechanisms of the hand-charged and motor-charged spring types shall be arranged so that release of the spring energy to close the circuit breaker can only be achieved by deliberate action. It shall not be possible for vibration or mechanical shocks to release the charged springs. Motor-charged spring mechanisms shall be arranged so that the charging is initiated automatically following a discharge and the necessary limit stops and switches for the automatic control of the charge once initiated, shall form an integral part of the mechanism. It shall be possible to hand-charge a motor-charged spring mechanism.

The closing solenoids of dc solenoid operated mechanisms shall be suitable for operation at a minimum of 80% of the nominal supply voltage, and shall not mal-operate or cause excessive vibration when energized at a voltage equal to that of the closing battery with the charger set at the maximum rate, or equal to that from a full wave rectified source designed for multiple simultaneous operation. Unless otherwise specified or agreed, this higher voltage shall be taken as 120% of the nominal supply voltage.

To facilitate maintenance and adjustment of contacts, it shall be possible to "slow-close" the circuit breaker, but this operation shall only be possible in the fully isolated position. Any necessary operating handle or lever shall be supplied.

3. Circuit breakers shall be provided with interlocks to ensure that:

   The breaker shall be open before operation of the circuit isolation device is possible.

   The breaker cannot be closed until the circuit isolation device has been fully operated.

   The breaker cannot be closed in the service position without completing the auxiliary circuits.

   The breaker cannot be "slow-closed" except in the fully isolated position.

   With hand charged or motor charged spring mechanisms, the springs cannot be discharged until they have been fully charged and until the means for charging has been removed or disconnected.

   Where key interlocking (Castell or similar) is employed, tripping of a closed-circuit breaker shall not occur if any attempt is made to remove the trapped key from the mechanism.

4. A set of safety shutters shall be provided on indoor metal-clad switchgear to cover each three-phase group of stationary isolating contacts. The shutters shall be opened automatically by a positive drive from the circuit breaker moving portion and when closed shall prevent access to the stationary isolating contacts. When the circuit breaker is withdrawn, each set shall be capable of being individually operated and of being padlocked in the closed position.

   To facilitate high voltage and current injection testing via the isolating contacts, a device shall be provided for fixing (not locking) the shutters in the 'open' position and for releasing them into the 'closed' position. The device shall be arranged to be cancelled by the circuit breaker moving portion to ensure the restoration of the automatic features of the shutters.

   Busbar shutters shall be colored red and labelled "BUSBARS" in large white letters. Shutters in bus-section units shall be colored red and shall be labelled with a large white arrow pointing in the direction of the section of busbars to which the isolating contacts are connected.

5. Indoor circuit breaker moving portions shall be fitted with positive guides so as to ensure correct alignment of the isolating contacts.

6. Indoor high voltage circuit breakers shall be provided with circuit and/or busbar earthing facilities. Circuit and busbar earthing shall be carried out through the circuit breaker and so arranged that the earthing operation is completed on closing the breaker by its normal local means of operation.

Selection of either circuit or busbar earthing shall only be possible after the circuit breaker has been fully isolated, and by means of a fully interlocked and labelled "SERVICE/EARTH" position selector which shall be designed to permit padlocking in any position.

Facilities shall be provided on all incoming feeder circuit breakers for earthing, the circuit side. On at least one circuit breaker panel in any section of busbar facilities shall be provided for busbar earthing. Where the switchboard incorporates a busbar sectionalizing panel, this panel shall have the busbar earthing facility and it shall be possible to earth either section from this panel.

When the circuit breaker is connected to an earthing location, tripping shall only be effected by the manual device on the operating mechanism and automatic tripping shall be inhibited. The manual tripping device shall be capable of being locked to prevent unauthorized operation.

The mechanical interlocks on the breaker shall remain operative when the circuit breaker is in either earthing position.

7. Indoor fixed pattern high voltage circuit breakers shall be provided with three-phase test sockets on the circuit side for high voltage and current injection testing. Test sockets shall be provided with a hinged, lockable access cover which shall be mechanically interlocked to prevent it being opened until the circuit breaker has been opened and isolated.

1.12 High Voltage Circuit Breakers

1. High voltage circuit breakers shall mean circuit breakers working at above 1000 volts. They shall comply with the requirements given below.
2. Vacuum circuit breakers shall incorporate means of measuring contact wear in-situ without the necessity to dismantle the breaker or mechanism assembly.
3. SF6 circuit breakers shall be fitted with pressure switch contacts for remote initiation of a gas failure alarm. Easily accessible means shall be provided for refilling the breaker with dry SF6 gas at the correct operating pressure after carrying out maintenance.
4. Enclosures for high voltage switches-fuses shall be metal-clad conforming to IEC 298.

1.13 Low Voltage Circuit Breakers

Low voltage circuit breakers (up to 1000 volts) shall be of the air break horizontal withdrawable pattern.

Earthing facilities through the circuit breaker are not required.

Miniature circuit breakers (MCB's) and molded case circuit breakers (MCCB's) shall comply with IEC 898 and IEC 947-2 and shall be fitted with thermal over-load and instantaneous magnetic short-circuit protection; this protection to be adjustable in frame sizes above 63 amps. Where earth leakage protection is specified, it shall be of the current operated type.

Current limiting fuses shall be fitted where necessary to provide the specified interrupting capacity. The ratings of MCB's and MCCB's shall be correctly coordinated with fuse ratings to achieve the necessary degree of discrimination. MCB's shall be rated in accordance with IEC 899.

MCCB's shall be operated by a toggle type handle and shall have a quick-make quick-break over-center switching mechanism that is mechanically trip free from the handle so that the contacts cannot be held closed against abnormal currents. Tripping due to overload or short circuit shall be clearly indicated by the handle automatically assuming a position midway between the manual on and off positions. All latch surfaces shall be grounded and polished. All poles shall operate simultaneously.

MCCB's shall be completely enclosed in a molded case. Non-interchangeable trip breakers shall have their covers sealed; interchangeable trip breakers shall have the trip unit sealed to prevent tampering. Ampere ratings shall be clearly visible. Contacts shall be of non-welding material. Arc extinction shall be accomplished by means of arc chutes, consisting of metal grids mounted on an insulating support.

The protective actions shall be so coordinated that overcurrents will be cleared by the thermal action; short circuits of relatively low magnitude will be cleared by the magnetic action; high fault currents above a pre-determined point will be cleared by the current limiting fuses. The current limiting fuses shall not be affected when the thermal and/or magnetic trip functions clear the circuit. Regardless of which tripping device serves to clear the circuit, all poles of the breaker shall simultaneously open automatically.

The breaker shall not be resettable until current limiting fuses which have functioned have been replaced by an identical or similar fuse and the cover refastened. The current limiting fuse shall have a visual means to determine which has operated and requires replacement when the cover is removed.

MCCB's used for motor protection shall provide instantaneous short circuit protection by means of a front adjustable magnetic element on each pole of the breaker. The adjustment button(s) shall have main setting points and mid-setting points following a linear scale so that each point has a significant value within calibration tolerances. Current limiting fuse may be incorporated into the circuit breaker where required, to cater for high interrupting currents.

All MCCB's shall be ambient temperature compensated. Compensation shall be accomplished to allow the breaker to carry rated current between 25°C and 50°C with tripping characteristics that are approximately the same throughout this temperature range.

1.14 Corrosion Protection

High voltage switches shall mean switches operating above 1 000 volts. They shall conform to IEC 265-1 as general purpose switches category II with normal service conditions adjusted as specified. Switches shall have rated voltages, normal current, breaking capacity and making capacity suitable for the system and load circuit being switched, or as specified.

Closing and opening mechanisms shall be of stored energy pattern both manually charged and released or as an independent manual operation.

The assembly shall incorporate an earthing switch connected to the feeder cable side of the main switch. This shall comply generally with IEC 129 with a minimum continuous current rating of 200 amps and making capacity and short time current rating to suit the system, or as specified. The operating mechanism shall be independent manual for both closing and opening. Mechanical interlocks shall be provided to:

Prevent closing of the earth switch unless the main switch is open.

Prevent closing of the main switch unless the earth switch is open.

High voltage combinations of switches and fuses shall conform to IEC 420. The switches shall conform to IEC 265-1 except that the rated breaking current shall be seven times the rating of the largest size fuse in the combinations. The switch closing mechanism shall be independent manual and shall provide stored energy for opening mechanically by fuse-striker or by manual release.

High voltage fuses shall be cartridge type, current limiting with striker pins, conforming to IEC 282-1. Current ratings shall be as required for the circuit protection or as specified. Fuses shall be accommodated within an air insulated chamber, the access door or cover of which shall be interlocked so that it can only be opened if the main switch is open and the feeder connections are earthed. It shall not be possible to open the earth switch or close the main switch if the fuse access door/cover is open.

Earthing switches for high voltage switch-fuses shall earth the feeder cable side of the fuse and shall otherwise be as required for high voltage switch units.

1.15 Air Break Isolators and Fuse Switches

Air break isolators and fuse switches mounted indoors or incorporated in indoor metal-clad switchgear shall comply with IEC 947-3 and shall be of the "on-load" type.

Operating mechanisms shall be fitted with mechanical "ON/OFF" indicators. Operating handles shall be of semi-flush or telescopic pattern to reduce front projection to a minimum.

Fuses in fuse-switches shall be of the HRC cartridge type.

lsolators and fuse switches shall be provided with means of locking in the "OFF" position.

Access to outgoing terminals of isolators and fuse switches shall not expose live incoming supply terminals or contacts.

1.16 Contactor Type Motor Starters

1. Contactor starters shall incorporate air break, SF6 or vacuum contactors. Contactors shall be selected to suit the particular duty and application but shall have a minimum standard of mechanical endurance of 3 million operations and electrical endurance of 150 000 on-load operations. The utilization category and duty class shall be as specified.

   Vacuum contactors shall be provided with means of measuring contact wear, and any necessary gauges or other measuring devices shall be provided.

   Starters shall incorporate HRC fuses unless otherwise specified. These fuses may be incorporated in the starter isolator as a composite fuse switch assembly. Overcurrent and earth leakage protection shall be incorporated together with all necessary auxiliary relays, contactors, timers, auxiliary fuses, wiring and terminals. Control and indicating facilities shall be provided on each starter.

2. Low voltage starters up to 1000 volts shall comply with IEC 9474-1 and shall incorporate contactors complying with IEC 947-4-1.

   Low voltage starters shall incorporate a triple pole fully interlocked load breaking isolating switch capable of breaking the stalled motor current. Molded case circuit breakers may be fitted, where specified.

   Where low voltage starters incorporate molded case circuit breakers, fault switching coordination between the circuit breakers and the contactors shall comply with IEC 947-4-1.

   Isolators shall be provided with an external operating handle, mechanical "ON/OFF" indication and facilities for locking in the "OFF" position. Operating handles shall be of the telescopic or semi-flush pattern to reduce front projection to a minimum.

   Starters shall be of the fixed or withdrawable pattern as specified. If withdrawable, facilities shall be provided for testing the starter control circuits and operation when withdrawn without the necessity for complete removal of the starter chassis.

   Where control circuit supplies and interlock circuits are broken via plugs on withdrawal of the starter, at least one jumper lead and plug assembly of each size and type shall be provided to facilitate testing in the withdrawn (isolated) position.

   Three-phase motor starters shall be complete with a triple pole hand reset thermal overload device with single phasing protection unless otherwise specified.

3. High voltage contactor starters above 1000 volts shall incorporate contactor complying with IEC 470.

   High voltage starters shall be of the fixed or withdrawable pattern as specified and shall incorporate facilities for earthing outgoing cables. Fixed pattern starters shall incorporate a fully interlocked triple pole off-load pattern isolator having three positions 'CLOSED'/ 'OPEN'/ 'EARTHED'. Interlocks shall be provided to ensure off-load operation.

   On withdrawable pattern starters, cable earthing shall be effected by means of a fully interlocked integral earthing switch arranged so that cables can only be earthed when the starter is withdrawn (isolated). Re-entry of the starter shall be prevented whilst the cables are earthed.

   Means shall be provided to permit control circuit testing with the main isolator open.

1.17 Switchboard

1. All individual components of control equipment associated with any item of plant shall be contained in a single control cubicle or panel.

   Instruments, relays, switches, lamps, pushbuttons and the like shall be arranged on the cubicle in a neat, functional and logical manner. Similar items shall be of the same type, style, pattern or appearance throughout.

   Instruments, controls and relays mounted on different panel sections but having similar functions shall be located in a physically similar position.

2. All instruments, gauges and meters which perform similar duties shall be of uniform type and manufacture. They shall be flush pattern, dust and moisture proof suitable for the environment in which they are installed. Where hinged covers are necessary, they shall be provided with locks. Indicating instruments shall be of the dial or digital type fitted with zero adjuster externally accessible from the front, have no parallax error and normal maximum reading at approximately 60% full scale. Dials shall be white with black scales and lettering not subject to fading. Scales shall be of such material that-no peeling or discoloration will take place with age under humid conditions.

   Motor ammeters shall be capable of withstanding the starting current and shall have a compressed overload scale.

3. Unless otherwise specified, all control circuit supplies for contactor starters shall be obtained from a 110 volts 50 Hz integral control transformer contained in the starter cubicle. In the case of multi-motor and composite boards, one or more master control circuit transformers shall be provided for each section of busbars in the switchboard to feed a group of outgoing starters via bus wires in the board. Each control transformer shall be busbar connected and shall be provided with isolation facilities, and primary and secondary MCB's.

   Transformers shall be of the double wound pattern and shall be provided with earth screens between primary and secondary windings. One end of the secondary winding shall be earthed.

4. Indicating lamps on panels shall be rated to withstand not less than 10% continuous over-voltage. Alternatively, lamps shall be transformer operated or of a low voltage with series dropping resistors. On dc operated lamp circuits, suitably rated resistors shall be connected across each lamp operating contact.

   Lamps shall be well ventilated and the design shall permit removal of lamp glasses and bulbs from the front of the unit.

5. Electrically operated circuit breakers shall be fitted with control switches of the pistol grip type, with spring return to the "neutral" position, and with an interlock to prevent repetitive closing without moving first to the "trip" position. They shall be capable of being padlocked in the "neutral" or "trip" position.

   Switches for control selection, motor control and other purposes shall have spade, tee or other approved shape handles.

6. Pushbuttons shall be colored as follows:

   START - green.

   STOP - red.

   "START" pushbuttons shall be effective only in selected circuits, primarily hand control circuits.

   "STOP" pushbuttons for motors controlled by circuit breakers shall be arranged to trip the circuit breaker and shall have an additional contact to interrupt the breaker closing circuit.

7. Where practicable, all fine wire operating coils and wire wound resistors shall be vacuum impregnated with an approved insulating varnish.

8. Terminal boards or blocks shall be of the type which clamps the wire securely and without damage between two plates by means of a captive screw. Pinch screw type terminal blocks will not be acceptable. The minimum size of terminal shall be suitable for a $4mm^2$ conductor. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled, and the voltage grouping and terminal board layout shall correspond with the wiring diagrams. Where approved, barrier-pattern screw or stud-type terminal boards are used, covers of transparent insulating material, which does not sustain combustion, shall be provided.

   Terminals which may be live when the main equipment is isolated from the mains supply shall be suitably labelled to reduce the risk of accidental contact. All terminals shall bear a permanent identification number or letter.

   Terminal boards shall be located adjacent to the point of cable entry and adequate space shall be allowed for terminating the cable tails on site.

   An extra 25% spare terminal shall be provided for terminating spare cable cores.

9. Fuses or MCB's and links shall be provided to enable any circuit to be isolated as necessary for maintenance and test purposes without isolating the whole panel. All fuses shall be of the HBC cartridge type. Fuse carriers and solid link carriers and bases shall be made of plastic molded insulating material of an approved make. Ceramic materials will not be accepted. Accessible live connections shall be efficiently shrouded and it shall be possible to change fuses with the circuit live without danger of contact with live metal. The fuses shall be rated to give maximum protection to the apparatus in circuit and the rating shall be inscribed on the fuse label.

   Earthing and neutral links in main supply circuits shall be of the solid copper bolted pattern.

   Fuses or MCB's and links functionally associated with the same circuit shall be mounted side by side.

   Descriptive circuit/function labels shall be mounted adjacent to all fuses or MCB's, the layout of which shall correspond to the wiring diagram.

10. Auxiliary switches shall be supplied as required for indication, protection, metering, control, interlocking and supervisory purposes. They shall be readily accessible and enclosed in a transparent dustproof cover. Adequate secondary disconnects shall be included where appropriate to enable the auxiliary switch to be wired to the fixed portion of the equipment.

    Two normally open and two normally closed spare auxiliary contacts shall be provided and shall be wired to suitably identify spare terminals.

11. Where volt-free contacts are specified on any equipment, e.g. a circuit breaker or contactor starter, they shall comprise contacts operated directly by the equipment but electrically separate such that no potential derived from the equipment appears at the contacts. Volt-free contacts shall be used to complete external control, alarm or indication circuits, the supplies for these circuits being obtained from an external source.

    Unless otherwise stated, these supplies will be from low voltage ac or dc sources and auxiliary isolating poles, e.g. on starter isolators, need not be provided.

12. Switchboard and panel wiring shall be carried out in 1000 volts grade PVC insulated cable. Flexible wiring shall be 600 volts grade.

    Wiring shall be carried out in a neat and systematic manner and securely fixed by insulated cleats or other approved methods and arranged so that access to any apparatus or connection point is not impeded. Wiring installed in trunking shall have a space factor not greater than 50%.

    Where wiring passes between compartments, the access hole shall be fitted with a suitable grommet.

    Sleeve type identification ferrules shall be fitted on all wires at both ends. The numbers and letters used shall correspond with the appropriate wiring diagram and shall read from terminals outwards.

The wires shall not be joined or broken into between terminal points.

Terminations for screw or stud terminals shall be of the claw washer pattern or equal, or of the crimped-on-ring type, the latter being preferred. Terminations of stranded conductors to clamp type terminals shall be of the crimped-on solid rod type.

Wiring for future equipment shall be provided as far as possible and all wires shall be terminated.

Not more than one core of either internal or external wiring shall terminate on any outgoing terminal. Where duplication of terminal blocks is necessary, suitable solid bonding links shall be incorporated in the design of block selected.

13. Switchboard cubicles shall incorporate anti-condensation heaters. The heater circuits shall be energised from a single-phase supply obtained from an independent power source.

    Individual floor mounting cubicles shall each be fitted with an anti-condensation heater together with a suitably positioned adjustable thermostat, rotary "ON/OFF" heater switch and MCCB protection.

    Multi-tier type cubicles shall have a cubicle heater and thermostat for each vertical panel section except that multi-tier motor starters may have individual heaters controlled by a normally closed contact on the contactor auxiliary switch in place of the controlling thermostat.

14. Switchboard for outdoor installation shall be provided with suitable sunshade for protection against direct sunlight.

1.18 Switchboard Safety Arrangements

Switchboards, control panels and all items of electrical control equipment shall be designed and constructed to provide a maximum standard of safety for all Operation and Maintenance procedures.

Multi-circuit switchboards shall be fully sectionalized and provided with dividing sheets and screens to give safe access to individual switchboard circuits, and to permit all normal Operation and Maintenance procedures to be carried out without interference to, or risk of accidental contact with live conductors or components of independent circuits within adjacent switchboard sections.

Access to circuit compartments or cubicles through hinged doors shall be inhibited by a positive interlocking arrangement, until the isolator or switching device feeding unscreened or exposed conductors or equipment terminals within the cubicle is switched to the "off" position.

lsolators, clearly labelled, shall be provided in such positions and connected so that maintenance can be carried out with maximum safety. This particularly applies to control circuits fed from a remote position. Where it is necessary to maintain certain components in a cubicle in a live condition when the isolator is in the "off" position such apparatus shall be screened and labelled to eliminate the possibility of accidents. Additionally, a system of removable insulated links or isolating type terminal blocks shall be provided to enable particular components to be isolated for maintenance purposes whilst retaining other essential circuits energized.

Terminals, connections, relays and other components which may be live when front access doors are open shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle when any door is opened.

Where several outgoing circuits occupy a common termination chamber, all copper work, cable lugs, terminations and terminal boards shall be fully screened or insulated to enable work on any one circuit to be carried out with other circuits live.

1.19 Protection Transformers

Protection and instrument transformers shall comply with the following:

1. Current transformers shall be of the bar primary pattern where practicable. Current transformers shall have a short-time current rating of not less than that of the switch panel in which they are

incorporated. For bar primary current transformers, this rating shall be for a period of 3 seconds and for wound primary designs, the rating shall preferably be for a period of 3 seconds but may be reduced to not less than 0.5 second subject to the approval of the Engineer.

Current transformers for high voltage equipment shall be resin encapsulated, except that for bar primary designs with ring type cores mounted on resin insulated bushings, alternative secondary winding insulation will be accepted, provided that an earthed screen is introduced between the toroidal winding and the bushing and that the toroid is adequately clamped either to the bushing or to the main structure.

Where multi-ratio current transformers are supplied, a label shall be provided, clearly indicating the connections required for the alternative ratios. These connections shall also be shown on panel wiring diagrams.

Secondary winding currents shall be 1A or 5A.

Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels shall be fitted on the exterior or the mounting chambers suitably located to enable reading without the removal of any cover.

Current transformers for balanced earth fault protection shall be designed for a stability of not less than six times the rated primary current.

Current transformers for unit protection schemes shall be designed for a stability of not less than the maximum through fault current of the units.

Where attracted armature relays are employed, the spill current with maximum stability conditions shall not exceed one quarter of the operating current of the relay.

Magnetization characteristics, calculated performance and protection setting shall be provided by the Contractor.

Current transformers for use in conjunction with a portable precision kWh meter shall be of class 0.2 accuracy. Other metering current transformers shall be of class 0.5 accuracy.

2. Voltage transformers (up to 1000 volts) shall be supplied where test metering connections are required to terminate at test terminal blocks. They shall have a winding ratio to give a three-phase voltage between lines of 110 volts. They shall have a rated burden, at the stated accuracy, in accordance with the requirements of all connected instruments, meters and relays and of any instruments or meters to which they may be connected via test blocks.

   The primary circuit shall be protected by HRC fuses having a short-circuit rating not less than that of the switchgear. The connections between the fuses and the switchgear primary conductors shall be of sufficient cross-section and be supported to withstand the short-circuit rating of the switchgear.

   The secondary circuit shall be protected by HRC fuses mounted as closely as possible to the secondary terminals. The fuses shall have safe access for renewal without the necessity for complete isolation of the switchgear.

3. Voltage transformers on high voltage (1000 volts and above) systems shall have a rated burden, at the stated accuracy, in accordance with the requirements of all instruments and meters to which they may be connected via test blocks. The windings shall be resin encapsulated. Voltage transformers for metal-clad switchgear shall be housed in naturally air-cooled, totally-enclosed sheet-steel enclosures which shall be of the isolatable pattern capable of being padlocked in the plugged-in position.

   Safety shutters shall be provided to cover automatically the fixed isolating contacts when the transformer is isolated, the means shall be provided to padlock the shutters in the closed position. The shutters shall be colored yellow, when the isolating contacts are connected to the feeder side of the circuit, and red, inscribed “BUSBARS” in large white letters, when connected to the busbars side of the circuit.

Connections to the primary isolating contacts shall have a short-time rating equal to that of the switchgear and shall be capable of carrying 200 amps continuously.

The primary winding shall be connected through cartridge type fuses incorporating current limiting resistances. These fuses shall be removable only when the transformer is isolated. Secondary circuit fuses shall also be provided and shall be readily accessible for renewal.

1.20 Protection Relays

Protection relays shall fully comply with the requirements of EN 142 or equivalent IEC.

Relays shall be contained in dustproof cases, shall be mounted on the front of the switchgear or relay panel. Auxiliary relays may be mounted within the panel but shall be accessible for inspection and wiring. Plug-in pattern relays shall have a positive means for retaining them in the service position.

Relay contacts shall be capable of making and breaking the maximum current which can occur in the circuit they control. Contacts for remote alarms and indications shall be volt-free, hand reset type.

Operation indicators shall be fitted to tripping relays and such other protection relays or relay elements as will enable the type of fault condition to be identified. Indicators shall be capable of being reset without the relay case being opened.

1.21 Emergency Stop Push Buttons

Emergency stop pushbuttons shall be provided and positioned in the immediate vicinity of the associated motor drive in all cases where:

1. There is no direct line of sight between the motor and the controlling starter; or
2. Where the distance between the motor and the controlling starter exceeds 5 meters.

Emergency stop pushbuttons shall be connected in control circuits so that they are effective under all operating conditions and shall have red mushroom headed pushes of the stay-put pattern. A deliberate re-set action shall be required before the drive can be put back into service and resetting of the pushbutton shall not restart the drive.

Where a “start/stop” pushbutton controlling station is specified, local to the motor drive the emergency stop pushbutton shall be integral with the local controlling station.

1.22 Direct Current Supply Systems (DC)

Batteries shall be of the nickel-cadmium type having cells contained in heat resistant, transparent, high impact plastic containers. Cell containers shall be clearly marked to show the maximum and minimum levels of electrolyte, and shall be provided with vented filler plugs. Cells shall be numbered consecutively. Cell terminals shall be of robust construction and shall be permanently marked to show their polarity.

Battery trays shall be factory treated with an electrolyte corrosion resistant finish, e.g. plastic coating.

Battery chargers shall be of the solid-state constant voltage type incorporating a self-protecting current limiting feature for protection against low battery volts and short circuits. Reverse battery protection shall also be provided.

Chargers shall be suitable for continuous operation in an ambient temperature of 50°C. Their output voltage regulation shall be not less than ±2% irrespective of ac mains input variations of ±10% for load variations from 0% to 100%.

Chargers shall be fitted with an “ON/OFF” switch, dc ammeter, and indicating lamps for “automatic charger” and “charger output failed”. In addition, volt-free changeover contacts shall be provided on relays to give remote indication of “charger supply failed” and “charger output failed”.

Battery and charger equipment shall be housed in well-ventilated sheet steel enclosures having front access doors. The enclosure shall be designed to provide total segregation of the battery and charger equipment.

Direct current distribution boards shall be as specified for distribution boards except that suitably rated load breaking double pole switches with HBC fuses for the incoming and outgoing circuits shall be incorporated.

Distribution boards shall be fitted with relays for battery earth fault and battery voltage low, with local lamp or flag indication and volt-free contacts for remote indication. A dc ammeter and voltmeter shall also be fitted to the incoming equipment.

1.23 Motors

1. All electric motors shall comply with the requirements of IEC 34.

   Constant speed alternating current motors shall be of the induction type suitable for operation on a three-phase supply and shall be capable of operating continuously, at rated torque, at any voltage between ±10% of the nominal value, and nominal frequency ±2 Hz.

   Direct current motors, which are to operate from batteries, shall be capable of operating under service conditions at any voltage between ±10% of the nominal value.

   Motors operating from rectifier equipment shall meet the voltage and frequency conditions required for ac motors.

   All motors shall, unless otherwise specified, be capable of running continuously at an output not less than 10% in excess of maximum power absorbed by the driven plant under any operating conditions.

2. Enclosures shall afford a degree of mechanical protection not less than IP54. Submersible motors shall meet the requirements of lP58. Motors for outdoor installation shall comply with protection class lPW 55.

   Totally enclosed motors shall be provided with suitable means of breathing and drainage to prevent accumulation of condensation.

   Motors for installation outdoors shall be provided with suitable covers for protection against direct sunlight.

3. Windings shall be impregnated to render them non-hygroscopic and oil resistant, and shall be braced to prevent any movement of the coils during all conditions of service.

   Motors operating in an ambient temperature not exceeding 50°C shall be insulated to IEC 85, with the limits of temperature rise applicable to Class B insulation.

   All motors shall, unless otherwise specified, be designed for direct-on-line starting, and 6 starts per hour, S4 switching duty to EN 6034-1 or equivalent IEC at maximum site ambient temperature.

4. Bearings shall be plain or roller type as appropriate, vertical shafts having approved thrust and guide bearings.

   Where necessary to prevent damage by any shaft currents which may be produced, the bearings and their lubricating and cooling systems shall be insulated from the bedplate or frame.

   Bearings shall be sealed or self-lubricated and provided with readily accessible filler. Dial type bearing thermometers with adjustable alarm and cut-out contacts shall be provided for large motors.

5. Embedded temperature detectors for stator temperature measurement shall be provided on HV motors. All detectors shall have the same characteristics and instruments shall be provided with adjustable alarm and tripping contacts.

6. Anti-condensation heaters shall be provided on all motors above 40 kW. The heaters shall be suitable for use on a single-phase ac supply and wired to a separate terminal box.
7. On slip-ring and commutator motors the brush gear shall be designed to operate without injurious sparking and with the minimum need for adjustment or replacement of brushes. Removable covers shall provide access to brush gear, slip-rings or commutator.
8. Terminal boxes shall be positioned to accept cables which rise vertically from below, or angled to accept cables without stress being introduced to the cable. Phase segregation shall be provided on power cable terminal boxes fitted to all high voltage motors.

   All terminal boxes shall be provided with disconnecting links and be designed so that the cable box may be removed without the necessity of breaking the cable termination. Alternatively, pre-molded cable connectors, with stress relief provisions for HV cables, may be employed provided that their use complies with the recommendations of the specialist manufacturer of such connectors.

1.24 Static Inverters

lnverters shall be solid state type and shall provide a single phase or 3-phase output as specified.

lnverters shall have the following characteristics:

Maintain an output frequency constant within ± 1% of nominal.

An adjustable ac output voltage of ± 5% at nominal dc input voltage.

A maximum deviation of ac output voltage of ± 2% over the entire ranges of load, dc voltage and power factor, whilst supplying a symmetrical load.

Be capable of supplying unbalanced ac loads to an extent and at a voltage deviation referred to the line-to-line voltage which shall be stated by Contractor for 3-phase inverters.

Be capable of continuous operation under the ambient temperature specified.

A limited overload capacity.

An in-built current limiting circuit to provide short circuit protection.

An ac output filter to limit the total harmonic voltage distortion across linear loads to 5%, over the entire ranges of load, voltage and power factor.

A dc input filter to ensure that the r.m.s. value of ac voltage does not exceed 5% of the dc voltage.

A totally enclosed floor mounting sheet steel enclosure with front access doors.

1.25 Fixings and Fixtures

All nuts and bolts shall be threaded in accordance with ISO standards and fitted with 3mm thick washers beneath bolt and nut.

All bolts, nuts, washers, except high tensile, for all ferrous parts shall be steel galvanized to ISO 1459-1460-1461 or equivalent, primed and painted hereof after assembly and tightening.

All bolts, nuts, washers and anchor plates, for fastening galvanized components or aluminum alloy components shall be of stainless-steel Grade 316S16 to EN 10250-4 or equivalent and shall remain unpainted. PTFE washers shall be fitted beneath stainless steel washers for bolt head and nut.

Holding down and anchor bolts, nuts, washers shall be galvanized steel to ISO 1459-1460-1461 or equivalent, and shall be painted after assembly and tightening.

Woodscrews shall be brass with round head or countersunk heads and single slotted for a standard screw driver.

Drilled anchor fixings for use on concrete structures shall be of a type approved by the Engineer's Representative.

All holes in concrete and civil works for anchor fixings or plugs for wood screws shall be made with a rotary drill.

Single shot cartridge tool fixings may be used only at the discretion of the Engineer.

2 CABLING AND EARTHING

2.1 Applicability

The following clauses specify the general requirements for the supply and installation of cabling and earthing systems. The general specification clauses shall apply where appropriate except where redefined elsewhere in the Specification.

2.2 Polarity

Power cables shall be connected between main switchboards, distribution boards, plant and accessories so that the correct sequence of phase colors is preserved throughout the system.

Cable cores shall be identified with the phase colors corresponding to those used in the electrical plant. The use of different phases on a number of single-phase circuits in one room shall be avoided wherever possible. If unavoidable, then the live cores shall be identified with their appropriate phase color. When more than one single phase circuit live conductor of different phase polarity is terminated in a common multi-gang switch or other apparatus, that equipment shall be sub-divided by metal or insulating material screens to segregate the different phase circuits. Danger labels shall be provided and fixed adjacent to the terminal equipment to warn of the presence of different phases.

2.3 Cables

Cables shall be delivered on robust cable drums with cable ends treated to form an effective seal. When a cable is cut from a drum, the cable end and the end left on the drum shall immediately be sealed in an approved manner to prevent the ingress of moisture.

Conductors shall be of high conductivity copper.

The Contractor shall ensure that each cable is of sufficient rating for its duty under both normal and possible fault conditions. In assessing the rating and cross section required for each cable, the following factors shall be taken into account:

1. Fault level and duration.
2. Ambient air and soil temperatures.
3. Soil thermal resistivity.
4. Voltage drop under steady state and transient conditions.
5. Loading under steady state and transient conditions.
6. Overcurrent settings of circuit breakers.
7. Disposition of cables.

Cable referred to as PVCSWAPVC shall be PVC insulated and bedded single wire armored cable with an overall PVC sheath. Non-magnetic armor of hard drawn aluminum shall be used on single core types.

Cables referred to as PVCPVC shall be PVC insulated and sheathed.

Power cables referred to as XLPESWAPVC shall be cross linked polyethylene insulated, single wire armored cable with PVC overall sheath. Non-magnetic armor of hard drawn aluminum shall be used on single core types.

Cables referred to as MICV shall be copper sheathed cables, with powdered mineral insulation and copper conductors with a PVC outer sheath to IEC 702-1. MICV cables shall be 1000 V rating.

All buried cables shall incorporate a metal tape termite barrier with PVC outer sheathing.

2.4 Cable Termination and Jointing

2.4.1 Cable Terminations

All PVCSWAPVC, PVCPVC and XLPESWAPVC cables shall be terminated with mechanical glands which shall be of a type to seal the cable against ingress of dirt and moisture and provide adequate mechanical support. Glands shall conform to EN 62444 or equivalent and shall have PVC shrouds and an earth tag at one cable end only.

Termination glands for armored cables shall provide a positive armor clamp both for cable support and for a high level of earth continuity.

Encapsulated termination techniques, either heat shrink and/or pre-molded, with stress relief provision for HV terminations, shall be employed for these cables.

All cable conductors shall be terminated in a suitable copper lug crimped or sweated.

Particular care shall be taken in the drying out and sealing of the ends of MICV cables and in the making of connections to boxes and fittings. The manufacturers' terminations shall be used throughout. MICV cable glands shall conform to IEC 702-2. Cable end seals shall be of the brass pot type.

The Contractor shall ensure that any special tools required for the installed MICV cable are made available to his operatives and that they understand and are competent in their use.

The ends of all cable shall be at all times temporarily sealed to prevent the ingress of moisture. When MICV cables are used in conjunction with equipment liable to vibrations, suitable terminal boxes shall be provided in the vicinity of such motors or equipment and the final interconnections shall be made by means of flexible cable or multi-strand wiring in flexible conduit.

Cable glands shall be protected by corrosion-resistant PVC hoods.

The cable termination and sealing equipment shall be obtained from the cable manufacturer, or other approved supplier, and shall be purpose-made for the type, size and grade of cable concerned. The application of these materials shall be strictly in accordance with the manufacturer's instructions.

2.4.2 Underground Cable Joints

The underground cable joints in power and auxiliary cable installations shall not be used unless specified.

Underground cable joints in power and auxiliary cable installations shall only be used (subject to the approval of the Engineer) in circumstances where cable route lengths exceed the maximum possible cable drum lengths.

All underground joints shall be by encapsulated jointing techniques.

Wherever it is necessary to remove the PVC sheath of a cable for jointing or termination, only the minimum length necessary shall be removed and the exposed armor or copper screen shall be protected by PVC tape or sleeves.

2.5 Cable Installation Within Buildings

Cables which are to be run on walls, ceilings or other building structures shall unless otherwise agreed by the Engineer, be secured on cable trays and ladders or enclosed in conduit or trunking.

Every cable shall be neatly run vertically or parallel to adjacent walls, beams or other structural members.

Suitable screens shall be provided to protect the cables run on the external surface of structures or above ground level, from the effect of the sun radiation. All screens used to protect the cables shall be of an approved design, securely fixed to the structure or ground and be fully ventilated.

All vertical cable runs shall be protected to a height not less than 450 mm above floor level by inverted cable tray, cable channel, conduit or other approved method.

Where the building structures incorporate covered floor trench systems, cables shall be installed on horizontal trays racked against the side(s) of the trench. Other support systems may be used for heavy power cables subject to the approval of the Engineer. The minimum vertical distance between horizontal trays shall be 300 mm. Adequate space shall be provided at the side of the trays to facilitate easy installation. Cables installed close to the bottom of the trench shall be arranged and spaced to allow adequate air circulation. No cables shall be laid direct onto the trench floor.

Where the structure incorporates general service ducts or trenches containing pipework, chemical lines and other services, all cabling shall be segregated from the other services and shall be run on the trench walls.

The Contractor shall supply all covers and associated steelwork for the structure and building cable trench systems. Trench covers shall be checker plate pattern.

Throughout the installation due regard shall be paid to the spacing of cables to maintain current rating, to prevent interference between power and signal cables, and to avoid unnecessary crossovers.

The spacing of clips, saddles and cleats shall be such as to prevent the sagging of the cables during their installed life. The method of fixing clips, etc., shall be by means of non-corrodible screws inserted into approved wall fixings.

Cable fixing on horizontal trays and ladders shall be arranged to secure the cables and maintain the specified cable grouping and segregation. The spacing of clips and saddles shall be not greater than 600 mm.

Cable hangers, cleats, saddles, brackets and similar supporting devices shall be of an approved type and of adequate strength for the cables they are supporting. They shall be treated to withstand site conditions without corroding. Self-locking plastic buckle clips and strapping shall not be used.

Where a number of cables are terminated in any particular item of equipment, special care shall be taken to ensure that the cables finally approach the equipment - from a common direction and are individually terminated in an orderly and symmetrical fashion.

2.6 Cable Tray and Ladders

2.6.1 Hot Dip Galvanized Trays

Perforated tray and cable support systems for dry structures shall be heavy duty hot dipped galvanized steel.

Wherever tray and ladder sections are cut and shaped on site, cut edges shall be dressed and painted with a coat of cold galvanizing compound within two hours of cutting and dressing followed by a further coat in accordance with the coating manufacturer's instructions.

2.6.2 Glass Reinforced Polyester (Grp) Trays

Cable tray systems in chemically corrosive locations and areas affected by the effluent shall be of pultruded glass reinforced ultra violet and corrosion resistant stabilized polyester pattern.

GRP cable tray systems shall be of the ladder type design having "Z" shaped side rails. Rungs shall be of the same material as the side rails and securely bonded in place. Rungs shall be mechanically locked into place by means of an intermediate side rail flange to prevent roll-over when cables are pulled into the tray.

Where appropriate GRP cable tray sections shall not be less than 6 m long and each, straight section shall be furnished with pre-punched holes for splice plate attachment. Trays shall be complete with all necessary fasteners, hold-down clips, splice plates, support systems, covers, etc.

Splice plates and cable fasteners used with GRP tray systems shall be fiberglass encapsulated stainless steel and shall be installed using torque limiting tools to prevent damage to the encapsulating coating.

2.6.3 Cable Tray Installations

Cable tray and ladder systems shall be installed using factory made supports, joints and junction/bend pieces.

Brackets shall be provided at a maximum of 1200 mm centers and be prefabricated hot dipped galvanized steel.

Fixing of galvanized trays shall be by means of non-corrodible screws inserted into approved wall fixings.

Where GRP tray systems are installed, all fixings and supports shall be stainless steel.

Bends and tees shall be prefabricated and have an inside radius of not less than 300 mm and where large cables are to be accommodated the radius shall be sufficient to fully support correct minimum cable radius.

Cables shall be fixed to trays by means of purpose made fixing clamps. Cable fasteners used with GRP trays shall be fiberglass encapsulated stainless steel.

Single core cables of the same circuit shall be laid and mounted in purpose made trefoil cleats.

Vertical tray systems shall be provided with protective covers to a height not less than 1000 mm above floor level.

Particular care should be taken on vertical rise trays providing adequate cable fixings to ensure distribution of load and security.

2.7 Cables Installed in the Ground

2.7.1 General

Power, control and signal/monitoring cabling external to, and interconnecting the main plant buildings, shall be installed in underground duct systems under permanently made-up areas, and shall be directly buried in trenches in all other areas.

The Contractor shall prepare drawings showing his precise requirements for cable ducts and trench work. The drawings shall detail the number of ducts required, the width and depth of trenches and the number and location of draw pits. These drawings shall be prepared in consultation with the Engineer and shall be approved before issue.

Cable routes shall be agreed with the Engineer.

The excavation and backfilling of trench works and the supply and installation of all cable ducts shall be the responsibility of the Contractor.

The Contractor shall supply and lay the sand bedding, supply and lay the cables, supply and lay sand blinding and supply and lay protective tiles and warning tape; he shall also supply and lay cable route marker posts after the backfilling and top soiling has been carried out.

2.7.2 Cables Direct in the Ground

When cables are buried, the bottom of the excavated trenches shall be free of sharp objects and shall be covered with sand or fine sifted soil to a depth of 50mm. The depth of excavated trenches for low voltage and high voltage cables shall be as specified.

Cables shall be unrolled from the drums so as to avoid loops and kinks, and care shall be taken when laying to avoid damage to the outer sheath.

Cables shall not be straightened completely after laying into the trenches to avoid excessive tensile stresses during backfilling or from subsequent settlement. After laying, cables shall be covered to a

minimum depth of 100 mm with sand or sifted soil. Cables shall be overlaid with protective interlocking tiles.

A warning tape shall be installed along the entire cable route. The tape shall be yellow colored polyethylene nominally 150 mm wide and 100 microns thick with the words CAUTION ELECTRIC CABLES BELOW in both English and Lebanese at regular intervals. The tape shall be installed approximately 400 mm above the associated cable(s).

Concrete marker posts shall be provided at 40 meters intervals and at points of change of direction along the cable run, each fitted with a suitably inscribed metal plate showing the voltage of the cable marked. Similar plates shall be provided and fitted to the outer walls of buildings at the points of entry. Marker posts shall also identify the position of any cable - joints.

2.7.3 Cables in Ducts

When installing cables in ducts the following procedures shall be used:

Cables shall be pulled in a straight line.

Rollers shall be positioned at the edges of draw pits both at the drawing-in and drawing-out points.

Plastic pipes and cable sheaths shall be lubricated with boiled-down soap of low alkali content or other approved lubricant.

A continuous check on the tensile forces shall be carried out by means of a strain gauge or a dynamometer attached to the rope holding the winch, with the latter resting on rollers.

A shearing pin or other tension limiting device shall be provided at the winch, which shall interrupt the pulling if the maximum permissible stress is exceeded.

The pulling rope shall be guided by rollers.

Cable ducts shall be made of UPVC or glazed earthenware material having a minimum diameter of 150 mm. Duct systems under roadways and areas liable to subsidence shall be encased in concrete.

2.7.4 Sealing of Cable Entry Holes

Where cables pass through walls below ground level, the point of entry shall be sealed against the ingress of moisture. Individual cable entry points shall be sealed by using Denso tape and “Denso-mastic” compound or similar approved materials. Multiple cable entries shall be sealed by multi-cable transit units (MCT) comprising steel frames and insert blocks. MCT’S shall be flange mounted on the inside surface of substructure walls or cable ducts.

2.8 Joint Boxes

The use of through and tee joints are prohibited on main and auxiliary control cable installations unless otherwise approved by the Engineer.

Junction boxes in auxiliary control cable circuits for the purpose of marshalling a number of cables feeding to a common item of equipment shall only be used with the written approval of the Engineer.

Any such junction box shall be of the wall mounting pattern with double terminals with cores ferruled and identified in accordance with the system schematic and cable diagrams.

2.9 Cable Identification

Every cable shall be permanently identified at each end by its cable number as shown on the cable schedule. Cable markers shall comprise an approved system of engraved plastic or stamped metal marker plates, secured to the cables by self-locking plastic buckle clips or similar fixings.

Cable marker plates shall also be installed at exit and entry points of buried ducts, exits from buildings and in such other positions as are necessary to identify and trace the route of any cable.

All power cables shall be connected at main switchboards and other items of plant so that the correct phase sequence and phase color coding are preserved throughout the system. Cables shall be identified with phase colors for three and four wire systems and red and black for single phase. On rotating plant, where to achieve the required direction of rotation it is not possible to connect the phase cores to the appropriately identified terminals, special core ferrules shall be fitted to identify each core with the terminal to which it is finally connected.

Control and instrument cables shall have individual cores identified by means of suitable permanent ferrules bearing the same numbers or letters at both ends and corresponding with terminals on equipment. Core identification shall occur at every point of termination using an approved system of ferrule markers.

Numbering shall read from the terminal outwards on all cores. At those points of interconnection between wiring where a change of number cannot be avoided, double ferrules shall be provided on each wire. The change of numbering shall be shown on the wiring diagrams of the equipment at which the change is made.

2.10 Earthing

1. A complete earthing system shall be provided for each equipment installation comprising a copper tape/conductor earth network and earth electrodes, which shall comply with the requirements of the BS 7430 or equivalent.

2. The earth networks shall comprise a main tape/conductor earth, conductor run around the structure with separate subsidiary branched copper tape/conductor connections taken from the main conductor to each item of electrical equipment, metal frameworks and castings, and to the neutral points of generators and power transformer secondary windings as appropriate to the method of system earthing.

   All metal pipework shall be bonded to the main earth network at the point of entry to a building.

   The earth network conductor shall comprise annealed high conductivity hard drawn copper strip which shall be supported on building or substation structures or cable trench walls by means of clamps suitably spaced. It shall be neatly run parallel to adjacent walls, ceilings and beams.

   The earthing of each item of electrical equipment shall be effected by bonding the earth tape/conductor to the special earth terminal provided thereon. Particular care shall be taken on cable termination boxes to ensure that the cable sheath and armor is adequately bonded to the frame of the item of plant to which the cable is connected. If the earth continuity through the cable termination gland is inadequate, a special copper connection shall be made, between the apparatus frame and the cable earth sheath and armor.

   Joints and connections in the earthing network shall be riveted, tinned and soldered, or brazed to the approval of the Engineer.

   Earthing on low voltage distribution and sub-distribution circuits of connected load capacity not exceeding 20 kW shall be affected by means of the metal sheath and/or armoring of cables which shall be securely bonded at each end to the metalwork or the apparatus concerned.

   Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and, should the design of such an item of apparatus not give adequate and lasting continuity through its structural body, additional earthing clips and conductors shall be provided to bond the cable sheaths or armoring together. Similarly, additional earthing clips shall be provided to bond the cable sheaths/armor to any piece of apparatus fitted with a special earth terminal should the earth connection of termination gland prove inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

   Where rigid or flexible conduit is used, an internal earth conductor shall be run which shall be securely bonded to the terminating or intermediate apparatus by means of a special earth terminal.

3. Unless otherwise specified two earth electrodes shall be provided for each installation.

Subject to determination by tests on Site, which shall be carried out by the Contractor, each electrode shall comprise either a system of interconnected driven rods, or alternatively buried copper plates.

The two electrodes shall be physically arranged and spaced to be electrically independent and leads from each shall be brought to an earthing bar located inside building or to common concrete disconnection chamber set in the ground. Two bolted copper links shall be provided in the disconnection chamber to enable each electrode to be disconnected from the system for test purposes.

Each electrode shall be capable of providing an effective earth of resistance not greater than the values specified, with the other electrode disconnected.

Earthing rods shall be steel cored with a metallic bonded copper outer surface of thickness not less than 0.38 mm and a total diameter not less than 16 mm. Rods shall be provided with special hardened tips and caps to avoid distortion when being driven into the ground. The rod extension length shall be of the screwed type arranged so that the diameter of the rods is not greater at the point of extension.

Each rod shall be provided with an approved non-ferrous clamp for the connection of the copper strips and these connections shall each be housed in individual inspection chambers set flush with the ground level.

Interconnections between electrode rods or plates and between the electrode test chamber and the main plant earthing conductor system shall be by stranded copper cable.

After the earth installation has been completed, the Contractor shall demonstrate to the Engineer that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the positions of the electrodes and buried connections. The markers shall be similar to those provided for cable routes.

2.11 Cabling and Earthing Record Drawings

Record drawings for the cabling and earthing installation shall include cable route drawings, block diagrams and cable schedules. Cable schedules shall detail the cable type, voltage rating, core size, installed length and terminal equipment. Core identification numbers shall be given for control cables.

Block diagrams shall illustrate the complete power and control cabling systems; each cable being identified as in the cable schedules.

Within buildings, cable route record drawings shall show to scale the location of all items of electrical plant and the route and method of installation of all cables, e.g., on tray, in trench, on hangers, in ducts and in conduits.

External cable route drawings shall show:

The route of the buried cable.

The depth of laying including any deviations to avoid local obstructions encountered during installation.

Positions of marker posts.

Positions of joints, test terminal points, draw pits, etc., located from marker posts or other agreed key points.

Distances of cable runs from pipe runs or other buried services.

Positions of earth electrodes, earth rod inspection chambers and interconnecting earth tapes/conductor.

2.12 Neutral Earthing Resistors

2.12.1 Resistors

The resistor elements shall be of the air insulated, air coded grid pattern, formed from continuous, rustles and non-magnetic alloy steel.

The resistor elements shall be mounted on mica or porcelain insulated steel rods. The resistor elements shall be assembled in tiers on interlocking insulators and supported on a welded steel framework. Interconnections between resistor elements shall be made using copper strip.

The whole resistor unit shall be designed to ensure ample strength to withstand the mechanical and thermal stresses imposed during the passing of the rated current.

The resistor voltage and current shall be as specified. The resistance value shall be that at the design ambient temperature, and the unit shall, unless otherwise specified, be capable of carrying the specified current for a minimum time of 30 seconds with a maximum temperature rise as stated in the schedules.

2.12.2 Enclosures

The resistor unit shall be provided with a sheet steel enclosure with side covers.

The enclosure shall be suitable for indoor or outdoor location as specified.

2.12.3 Connections

The resistor unit shall be provided with either cable termination facilities or porcelain top bushing as specified. A stud, insulated from the resistor unit metalwork shall be provided for the main earth connection. A separate stud shall be provided for the earthing of the metalwork.

2.12.4 Finish

Unless otherwise specified, all metalwork shall be hot dipped galvanized.

2.13 Lightning Protection System

Lightning protection system shall be provided for the buildings in accordance with IEC 1024-1.

Lightning pole shall be connected to an earth rod separate from the earth networks of the installations.

3 BUILDING SERVICES

3.1 Electrical Services

3.1.1 Applicability

The following clauses specify the general requirements for the supply and installation of electrical services for buildings and area throughout the works. The general specification clauses shall apply where appropriate except where redefined elsewhere in the specification.

3.1.2 Distribution Boards

Distribution boards shall be of zinc coated mild steel sheet construction of adequate thickness, suitably braced to form a rigid structure. Exterior corners and edges shall be rounded to give a smooth overall appearance. Doors shall be fitted with gaskets and shall be easily removable to simplify installation. Each distribution board shall be arranged for top and bottom cable entry and shall be provided with removable termination plates and space to enable cables and conduits to be neatly grouped and terminated. Distribution board shall be wall or floor mounted and shall, when specified, incorporate on-load isolators which shall be front of panel operated with “ON/OFF” indicators and capable of being padlocked in the “off” position. Distribution board shall incorporate combinations of single pole and neutral and triple pole miniature circuit breakers (MCB’s) as specified.

Each bank of MCB’s shall be clearly identified with its appropriate phase colour/code, and the mounting framework for the banks of MCB’s shall be easily removable to simplify installation. Adequate phase barriers and shields shall be fitted to ensure that, after installation and wiring, all bare terminals and wires are covered to prevent accidental contact with live conductors when resetting MCB’s.

MCB’s shall be rated to afford “close” overcurrent protection to circuits as defined in the IEC Recommendations.

Distribution boards shall incorporate neutral bars or terminal assemblies providing an independent terminal for each MCB circuit.

The termination of circuit cables at distribution board shall be neat and slack left to enable complete internal assembly to be partly removed for inspection without disconnection. Neutral conductors shall be connected to the bar in the same order as the phase conductor to the busbar.

Each distribution board shall be complete with a permanent circuit identification chart, mounted within the front door. This chart shall be permanently and legibly filled in as circuits are completed.

3.1.3 Conduits

Conduits shall be hot dipped galvanised steel. Conduits shall be neatly run on the surface or sunk as specified and shall be installed so as to permit complete rewiring without the need to remove false ceilings or wall cladding materials or carry out builders work.

Only continuous lengths of buried conduit shall be installed between boxes. No joint boxes shall be installed in the floor screeds. Conduits crossing expansion joints shall be fitted with couplings of approved manufacture with an earthing clip at each side of the coupling, connected by the correct size of tinned copper stranded wire.

Inspection couplers may be used in long runs to facilitate drawing in cables.

The ends of the conduit laid or set in formwork prior to concreting shall be temporarily sealed off with a coupler and a solid brass plug.

Particular care shall be taken to ensure that no water is allowed to enter the conduit and all conduits shall be arranged with adequate ventilation and drainage. Inaccessible junction boxes will not be allowed.

The sizes of conduit used shall be determined by the number of cables to be drawn in, but conduit smaller than 20 mm diameter shall not be used.

Fixings to surfaces of walls shall be by means of spacer bar saddles securely fixed by screws. Where conduits are concealed or laid in construction floors, they shall be held in position with substantial fixings of a make and pattern to be approved by the Engineer.

Surface run conduits shall be supported at intervals in accordance with the following schedule:

Size	Interval
20 mm	1.2 m
25 mm	2.0 m
32 mm	2.5 m

Where bends and sets occur in the conduit run, the conduit shall be securely fastened at a distance of 225 mm either side of the diversion.

The conduits shall be screwed into spout outlets of conduit boxes or, where fixed to boxes drilled with properly sized clearance holes, they shall be secured by means of sockets and hexagon smooth brass bushes. Threads shall be cut clean and all burrs shall be removed with a reamer.

Any exposed metal such as ends of conduit or exposed threads cut on site shall be treated by a cold galvanising compound or lead based anti-corrosive paint.

Any bends and sets shall be formed in the conduit itself. Factory made bends shall not be installed without the written permission of the Engineer.

Standard junction or adaptor boxes shall be provided at all junctions and at sharp changes of direction.

Junction and adaptor boxes shall be made from galvanised steel and shall be provided with gasketed flat covers secured with brass screws.

Weatherproof boxes and accessories shall be used outdoors.

Conduit ways shall be installed for telephone services run as for other conduit with a single cable pulled in and left for draw-in purposes.

For telephone points, conduits shall be terminated at flush standard boxes each with a stainless-steel telephone outlet plate.

3.1.4 Flexible Conduits

Where the conduit system terminates at any equipment requiring a non-rigid connection, a flexible conduit shall be installed of the PVC or PVC sheathed metallic type fully watertight with purpose made connection adaptors.

Each flexible connection shall include not less than 400 mm length of flexible conduit and a separate earth conductor shall be run within the conduit connected to the earth terminals in the equipment and the fixed conduit run. The flexible conduit shall not be used as an earth continuity conductor.

3.1.5 Trunking

Trunking shall be manufactured from heavy gauge continuous hot dipped galvanized steel. Each length shall be supplied with the necessary connection sleeves and shall have sides suitable for flush fitting.

The Contractor shall ensure that the size of trunking is adequate for the number of cables passing through it, but the minimum size shall be 50 mm x 50 mm. Bends, tees and intersections shall be of the gusset type and manufactured by the maker of the trunking and to similar standards. Trunking shall be fixed to ceilings by means of a secure and permanent fastening. Where standard lengths of steel trunking are cut, the Contractor shall, prior to assembly, treat the cut edge with a cold galvanising compound or lead powder based anti-corrosive paint.

3.1.6 Wiring

Cables for drawing into conduit shall be single copper core PVC insulated, non-sheathed, 1000 volts grade and shall be supplied by an approved manufacturer. Insulation shall be coloured to indicate phase and neutral.

The conductor sizes shall not be less than 1.5 mm² for lighting circuits, and 2.5 mm² for socket outlet circuits.

No conduit serving a single-phase socket outlet, lighting point or switch shall contain more than one phase.

Wiring shall be carried out on the looping-in system and no joints other than at loop-in points will be allowed.

3.1.7 Socket Outlets

All socket outlets shall incorporate an earth continuity pin or, subject to the approval of the Engineer, a scraping earth contact. Socket outlets of differing voltages shall have differences in plug dimensions and/or incorporate the appropriate keyway interlock for supply discrimination.

Switch socket outlets shall incorporate dolly type switch levers, either fully recessed or having a raised surround to prevent damage or inadvertent operation.

Socket outlets shall be of the shuttered pattern or, subject to the approval of the Engineer, shall be fitted with spring operated flap covers.

Each socket outlet shall be complete with a steel mounting box incorporating an earthing terminal and a metal cover plate.

Special care shall be taken to ensure that all fittings are securely fixed truly vertical, and that in the case of a flush mounted socket outlet, the mounting box is fitted flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

3.1.8 Lighting Switches

Interior lighting switches shall be supplied complete with metal box, cover plate and fixing screws.

At multi-switch positions, the switches shall be contained in multi-gang boxes.

Exterior lighting switches shall be metal-clad, galvanised and watertight, with rotary switch action.

All switches shall be securely fixed truly vertical and flush mounted switches shall be flush with the wall finish so that the overlapping cover plates seat onto the rims of the boxes.

3.1.9 Bulk Switching Contactors

Bulk switching contactors (e.g. for large lighting or heating loads controlled from a single switch) shall comply with IEC 947-4-1. The contactors shall be continuously rated for the duty specified and shall have a minimum utilization category AC1 and shall have an intermittent duty Class 1 with the characteristic mechanical endurance of that class.

Contactors shall be single pole or triple pole as required, each type with a neutral terminal.

Where contactors are not integral with main switchboards, enclosures shall be constructed similar to those for distribution boards and shall have a minimum protection characteristic lP52 to IEC 529.

3.1.10 Lighting

Luminaires shall be complete with all supports, suspensions, flexible cables, pendants and plugs. They shall be connected to the main circuit wiring with heat resisting flexible cables of a minimum core size of 24/0.20 mm insulated with silicon rubber.

The earthing of all luminaires shall be by a separate core in the connecting flex of cable securely bonding the earth terminal of the fitting to that of the interconnecting cables. Pendant chains or conduit support tubes shall not be used as a means of earthing.

Where weatherproof luminaires are installed, all cable entry and securing holes shall be adequately sealed to prevent ingress of moisture.

Fluorescent luminaires shall have two suspension or fixing points.

The length of fluorescent tubes shall be not greater than 1200 mm.

When luminaires are installed in areas incorporating suspended ceilings, they shall not be attached to or transmit load to the suspended ceilings unless the ceiling and lighting is of integrated design with the appropriate supports.

Where high bay discharge luminaires are suspended from the structural ceiling, the connection between the fitting and fixed wiring shall be by plug and socket to facilitate removal of the complete fitting.

Lamp holders for flexible pendants shall be of the all insulated skirted pattern with cord grips.

The point box suspensions and other parts of the luminaires shall be erected at times to suit the building programme for finishes. The glassware, diffusers, shades, lamps and tubes shall not be fitted until all building work is complete.

Fittings shall be left clean inside and outside and be ready for use; fluorescent fittings shall be suitable for switch start operation.

Fluorescent tubes shall be of energy efficient type and of an approved manufacture and standard white.

Incandescent lamps shall be of an approved manufacture with metal coiled filaments, gas filled and pearl in all sizes. Bayonet type fixtures shall not be used for lamps rated above 100 watts.

Exterior luminaires for site and area lighting shall be of the outdoor, weatherproof, anti-vandal, high pressure sodium vapour or metal halide type.

Security lighting shall be designed so as to be inaccessible to intruders.

The level of required illumination is at minima for:

Outside ways	20 luxes.
Inside ways and stairs	100 luxes.
Rooms inside buildings	300 luxes.
Offices inside buildings	500 luxes.

3.1.11 Emergency Lighting

Emergency light fittings shall be designed to provide a level of illumination under mains failure in compliance with BS 5266 Part 1 or equivalent.

Emergency lighting fittings shall be self contained, incorporating fluorescent lamp(s), battery charger and mains failure relay.

The fittings shall be fully automatic in operation, providing instant illumination in the event of mains failure for a duration of 3 hours. The battery shall be automatically recharged when the mains supply is restored.

Alternatively self-contained emergency power modules may be incorporated into the normal lighting luminaires, such fittings being distinctively labelled for identification.

3.2 Heating, Ventilation and Air Conditioning Plant

3.2.1 Applicability

The following clauses specify the general requirements for the supply and installation of heating, ventilating and air conditioning plant to be provided throughout the Works. The general specification clauses shall apply unless redefined elsewhere in the Specification.

3.2.2 Packaged Air Conditioning Units

Packaged air conditioning units shall be one piece air to air electric cooling units, each comprising an air cooled condensing section containing compressor/condenser coil and cooling fan and an air handling section containing return air/fresh air dampers, filters, direct expansion cooling coil, electric heater battery and centrifugal fan. The units shall be complete with all internal interconnecting pipework and control equipment and shall be supplied as a single packaged unit suitable for direct site installation.

Each packaged unit shall be housed in a totally enclosed fabricated steel floor-mounting cubicle, complete with removable panels or doors to facilitate access to all component parts for maintenance purposes. The units shall be designed for outdoor mounting and all component steel parts shall be hot dip galvanised. The units shall be installed on raised anti-vibration mountings.

The air handling section shall incorporate air filtration, air mixing and fan components. Air mixing dampers for return air and fresh air control shall be galvanised steel construction individually adjustable with damper rods, rotating in nylon bearings.

Air filtration shall be by cleanable filter cartridges located on slides for ease of access. Air filtration shall have an efficiency of not less than 90% based on EN 779.

The condenser coil shall be constructed of seamless copper tubes, arranged in staggered rows, mechanically expanded into aluminium fins.

The condenser fans shall be propeller type providing vertical air discharge. Fan blades shall be statically and dynamically balanced, protected above by anodized fan blade guards. Each fan shall be driven directly by an individual motor.

Compressors shall be of the serviceable hermetic type. The compressor and fan motors shall be suitable for continuous 380 Volts, three-phase, 50 Hz operation.

The units shall be complete with all motor and refrigeration control equipment, factory wired and suitable for direct connection to the power supply. All control equipment shall be contained in an integral but fully segregated cubicle compartment with lockable hinged access doors. The units shall be suitable for pushbutton starting locally, or from a remote control station.

3.2.3 Individual Room Air Conditioning Units

Each individual room air conditioning unit shall be of the through the wall pattern comprising two sections for indoor and outdoor equipment divided by an insulated steel bulkhead. The indoor section shall contain the evaporator electric heater battery, centrifugal fan, electrical terminal block and all electrical capacitors. The outdoor section shall house the compressor, condenser and propeller fan. The entire unit shall be mounted on a slide-out chassis within a weatherproof cabinet with removable front panel.

The compressor shall be hermetically sealed and resiliently mounted.

The evaporator shall be a single pass copper coil with light gauge aluminium fins and with an automatic thermostat to prevent excessive frosting.

The condenser shall be a copper coil with aluminium fins.

Filtration shall be provided by a washable filter accessible from the front.

The unit shall be suitable for continuous operation in an ambient temperature of 45°C.

3.2.4 Packaged Air-Cooled Water Chillers

Packaged air-cooled water chillers shall be completely factory assembled, including all interconnecting refrigerant piping and internal wiring of controls, and shall be mounted on a steel base which shall accommodate the air-cooled condenser, compressor and cooler. The units shall be delivered complete with full operating charge of the refrigerant.

Frames and panels shall be fabricated from heavy gauge galvanised steel, complete with removable panels to facilitate access to all component parts for maintenance purposes. The compressors shall be of the hermetic reciprocating type with all rotating parts statically and dynamically balanced. The compressor shall have a forced feed lubrication system using a reversible positive displacement type oil pump.

The compressor shall also include a suction strainer, oil strainer, crankcase oil sight glass, crankcase oil heater and back seating seal-cap suction and discharge stop valves. The compressor shall be mounted on spring isolators.

The evaporator shall be direct expansion shell and tube type with refrigerant in the tubes and liquid to be chilled in the shell. The water connections shall be fully accessible without going through the condenser sheet metal panel section.

The condenser coil shall be constructed of seamless copper tubes, arranged in staggered rows with aluminium fins. The condenser shall include as an integral part of the design a sub-cooling circuit. The condenser coils shall be of a “V” bank arrangement and shall be fully protected by sheet metal panels.

The condenser fans shall be propeller or axial flow type, providing vertical air discharge. Fan blades shall be statically and dynamically balanced, protected above by anodized fan blade guards. Each fan shall be driven directly by an individual motor. Each packaged chiller shall be complete with a built-in control centre. The control panel shall be split into two compartments, one housing the power circuits and one the auxiliaries. The control panel shall be complete with weather proof doors. The control panel shall include but not be limited to the following items:

High- and low-level refrigerant pressure cut-outs.

Low water temperature thermostat.

Control thermostat.

Motor starters.

Overload relays.

Time delay relays for starting compressors in sequence.

Fuses.

“On-off” switches for each compressor and reset pushbuttons.

Auxiliary terminals for interlocking.

Anti-short cycling device.

The units shall be suitable for operating continuously on a three-phases 50 Hz supply at an ambient temperature of 45°C.

3.2.5 Air Handling Units

1. Air handling units shall comprise a number of sections combined into ventilation or air conditioning units.

   Ventilation units shall be any combination of a fan section, panel filter, bag filter, mixing section or intake damper and sand trap louvers.

Air conditioning units shall be any combination of a fan section, cooling coil, electric heater, filter and mixing section.

2. Each section shall consist of a rigid assembly, formed from enclosure panels, constructed from double skinned galvanised steel sheet with 25 mm mineral wool internal insulation, resting on supporting beams.

   The different unit sections shall be assembled on robust clamping strips provided with seals to prevent air leakage. Inspection panels shall be provided with quick-acting opening locks.

3. The air filter section shall consist of disposable type filter bag cartridges located on slide rails for ease of replacement. Each filter bag cartridge and slide rail shall be provided with seals.

   The filter type shall be in accordance with ASHRAE 52 and filter efficiency shall be to EN 2831 or equivalent.

   Each filter section shall be provided with two spare complete sets of filter cartridges.

   Pre-filters shall be of the disposable panel type, with filter media of fibreglass. Filters of this type shall have an efficiency of not less than 90% based on the test specified in EN 2831 or equivalent with test duct No. 2.

   A manometer shall be titled to each filter section, arranged for measuring the pressure drop across the filter.

4. The mixing section shall contain two sets of dampers for mixing the outside and recirculated air.

   The dampers shall be of galvanised steel sheet double skinned construction and shall be interlinked externally to the casing. The dampers shall be individually adjustable with the damper rods rotating in nylon bearings.

5. Direct expansion cooling coils shall be provided where specified. They shall be of the extended surface, non-ferrous, fin type.

   The casing shall be constructed of heavy gauge galvanised steel. Coils shall have suction tapping located to permit universal mounting of the coil for right- or left-hand airflow and shall have equal pressure drop through all circuits. All long coils shall have stays to hold the fin-tube assembly in place. Primary tubes shall be seamless copper tube brazed into a heavy gauge header tube with intruded holes to allow for expansion or contraction of small radius return bends. Secondary surfaces shall consist of copper fins mechanically bonded on to the copper tubes. The coil fins and tube shall be electro-tinned after assembly. Brass liquid distributors of the pressure type shall be provided. Loading of each circuit shall maintain the refrigerant pressure drop within adequate limits to prevent loss of coil capacity.

   Coils shall be factory air tested to 2100 kN/m² under water. Coils shall be dehydrated and sealed after manufacture.

6. Chilled water-cooling coils shall be constructed as described for direct expansion cooling coils. The primary tubes shall be seamless copper with secondary surfaces of copper fins, mechanically bonded to the tubes and electro-tinned after assembly. Tubes shall be brazed into copper headers and filled with screwed male copper connections. Vents and drains shall be provided at the highest and lowest points.

7. All cooling coils shall have a maximum air velocity across the coil not exceeding 2.5 m/s to prevent moisture carry over. A condensate tray shall be provided at the base of the cooling coils complete with a drain connection. The condensate drip tray shall be coated with corrosion resistant paint.

8. Electric heater batteries shall be arranged to balance the electrical load over three phases. The heating elements shall be removable for cleaning and inspection. The connections from each heating element shall be taken to an accessible terminal box arranged for conduit entry. Each element shall be separately fused.

3.2.6 Fans

1. Fans shall be provided as specified. Each fan shall be capable of providing the required duty when tested in accordance with EN 848 or equivalent.

   To standardise fan performance, standard air shall be taken as having a weight per unit volume of 1.2 kg/m³, corresponding to atmospheric air at a temperature of 20°C, a barometric pressure of 1013 mbar and a relative humidity of 50%.

   All rotating assemblies shall be balanced both statically and dynamically after assembly in the manufacturer's works.

2. Axial fans shall be of aerofoil cross-section and of the single stage type or the multi-stage contra-rotating type, with each impeller driven by a separate motor, and mounted in a cylindrical casing. The blades of each impeller shall be fabricated from die cast aluminium, with pitch angles adjustable without removal from the fan casing. Balancing shall not be affected by altering the pitch angle.

   Casings shall be rigidly constructed from heavy-gauge hot-dipped galvanised steel sheet, with the overall length containing the impeller and the motor. The casing shall be provided with flanged connections and with two inspection doors incorporated diametrically opposite to each other.

   The impellers of the fans in the Chlorine House duct system shall be non-adjustable bifurcated rigid PVC pattern with non-overloading characteristics. The motor casing and fan support metalwork shall be constructed of hot dipped galvanised steel and protected with an approved chlorine resistant rubber-based paint.

   Motor bearing arrangement and bearing ratings shall permit continuous fan operation in the vertical or horizontal position. Ball or roller bearings shall be used.

3. Centrifugal fans shall be double-inlet or single-inlet. The fans shall be V-belt driven with backward or forward curved impellers. The fans shall consist of galvanised steel casing, fan impeller shaft and bearings, motor, steel frame, anti-vibration mountings, belt drive, pulleys and guards. The steel frame shall have adjustable rails. The fans shall be provided with an inspection cover.

4. Propeller fans shall be suitable for ring mounting or diaphragm mounting. The impellers shall be of steel or aluminium and fastened to the hub or formed with the hub in one piece. Ball or sleeve bearings may be used. The motor and impeller shall be a complete integrated unit. Anti-vibration mountings shall be fitted. Unless otherwise specified, the arrangement shall be with the motor upstream of the impeller. All fans impellers shall be finished with corrosion resistant coatings.

5. Air intakes and exposed fan moving parts shall be protected by rigid galvanised wire guards. Access shall be provided for measurement of shaft speeds and belt tension.

6. Roof extract units, where provided, shall be fitted with propeller or mixed flow type fans.

   The housing shall be constructed from corrosion resistant spun aluminium with a glass fibre base and weathering skirt for kerb mounting.

7. Where duplicate extract fan units are specified for toilet areas, each fan shall provide the full air flow required. The fans shall be connected in parallel and arranged for automatic changeover upon failure of the duty fan. Either fan shall be capable of being selected as the duty fan. In the event of failure of the operating fan, an airflow switch shall detect the failure and immediately activate the standby fan. A damper shall be provided to prevent back feed of air through the idle fan. A warning light shall be provided to indicate fan failure.

8. Ceiling mounted ventilation fans shall comprise capacitor start and run type motor, supporting down rod and three bladed fans. Blades shall be of steel. Each unit shall be complete with a surface mounted six speed and off-speed regulator.

3.2.7 Air Distribution

1. Grilles, diffusers and louvers shall be provided throughout and shall be sized to meet the requirements of the system and in accordance with approved design. Diffusers, grilles and louvers shall be constructed of spun anodised aluminium.

   Supply and return air grilles and diffusers shall incorporate key operated, opposed blade, manual, volume control dampers.

2. Ceiling mounted and duct mounted supply air diffusers shall incorporate removable and adjustable cores to provide a full range of air control. Return air diffusers shall match the supply air diffusers within the same space.

   Ceiling mounted diffusers shall be installed flush with the ceiling surface on duct extension collars arranged so that no load is imposed on the ceiling structure.

3. Supply air grilles shall incorporate double deflection, individually adjusted, air foil blades with front blades arranged parallel to the grilles longest side.

   Return air grilles shall be of the fixed horizontal blade pattern.

   Transfer grilles shall be of the single deflection fixed horizontal blade pattern.

4. External intake louvers shall be of the sand trap pattern. Each louver shall comprise fixed pattern, extruded aluminium, vertical mounted blades designed to form an effective sand trap. The intake louver frame structures shall incorporate an effective vermin screen, external sand drainage holes, removable bottom cover plates for cleaning, and shall be designed for mounting into the building structure.

5. The size of the louvers shall be such that the face velocity does not exceed 0.5 meters per second and at this velocity shall be capable of removing 85% of a typical desert sand and dust mixture from the incoming air.

6. The pressure loss across the louvers at 0.5 meters per second face velocity shall not exceed 25N/m².

7. External exhaust louvers shall comprise fixed pattern, extruded aluminium, horizontal mounted blade incorporating an effective vermin screen, and shall be designed for mounting into the building structure. The louvers shall be fitted with automatic non-return dampers incorporating edge seals to provide a fully air tight seal when closed.

3.2.8 Ductwork

1. The ductwork and all component fittings for installation in Chlorine House shall be constructed of unplasticized polyvinyl chloride (uPVC) extruded sheets and circular sections to EN 3757 and EN-ISO 3506 or equivalent.

   The ductwork and all component fittings in all other areas shall be constructed from hot-dipped galvanised steel to EN 10346

2. PVC duct systems shall be designed and constructed in accordance with the Heating and Ventilating Contractors Association (HVCA) Specification DW151 or equivalent.

   Ductwork joints shall be flanged with neoprene gaskets secured with cadmium plated mild steel bolts.

3. Galvanised steel duct systems shall be designed and constructed in accordance with the HVCA Specification DW141 and DW144 or equivalent for low velocity duct systems.

   Ductwork shall be constructed with lap or standing seams. Normal cross section joints shall be spigot and socket slip joints with a minimum 50 mm overlap. Bolted flange joints shall be provided for all fan and duct fitting insert sections. Lap joints and seams shall be sealed and riveted. Flanged joints shall incorporate neoprene gaskets and shall be secured with cadmium plated steel bolts.

4. Air flow control, non-return and fire barrier dampers shall be provided as required.

   Air flow control dampers shall be of the opposed blade pattern and provided with external operating handle with position indicator and means of padlocking in any set position.

   Dampers in uPVC ductwork shall be constructed of uPVC coated galvanized steel. Operating shafts shall be stainless steel.

   Fire dampers shall be of the single blade, hinged, self-closing pattern. Dampers shall be held open with fusible links set to release the damper at not greater than 72°C.

   Duct access openings shall be provided wherever necessary for plant routine maintenance, lubrication and adjustment. Hinged plates and removable covers shall be gasketed and secured with bolts.

   Duct test holes shall be provided for system balancing and commissioning.

5. Support brackets and fittings for all ductwork shall be of hot-dip galvanised steel.

   Fans, dampers and other duct inserts shall, wherever possible, be supported independently from the ducts to which they connect.

   Duct sleeves shall be provided where ducts pass through floors and walls. Duct sleeves shall be sealed after installation by an approved method.

   No duct support fixings shall be made to the building structural cladding.

3.2.9 Thermal Insulation

1. Thermal insulation shall be provided for all air conditioning ductwork systems. Each duct or pipe shall be individually insulated and shall have a complete vapour seal. Supports shall not be in direct contact with the pipe or duct.
2. Ductwork within plant rooms shall be insulated with aluminium foil-faced rigid fibreglass slabs 50 mm thick. The slabs shall be securely held in position with adhesive and 50 mm x 50 mm aluminium angles fitted as additional protection on all corners. Ductwork over 900 mm size shall be further held in position by means of stick clips and washers. The whole shall then be encased in a layer of heavy quality canvas, and sealed with a vapour sealer.
3. Internal ductwork outside plant rooms shall be insulated with aluminium foil-faced rigid fibreglass slabs 50 mm thick applied with an adhesive and vapour sealed.
4. External ductwork shall be insulated as described for plant room ductwork, then further protected with a layer of 2-ply aluminium foil-faced roofing felt which shall be well lapped at joints and secured with 32 mm mesh x 19-gauge galvanized wire netting, and the whole vapour sealed.

3.2.10 Noise Control

Acoustic attenuators shall be provided as required to achieve the noise levels specified. Attenuators shall be uncased units for plenum chambers and builders' ducts, or cased units elsewhere. Cased units shall be of the straight-through splitter bend, lined bend or straight-through cylindrical type.

Rectangular splitter type attenuators shall be constructed from galvanised mild steel sheet of the following thickness:

Longest side up to 680 mm - 1mm.

680 mm and over - 1.6mm.

Galvanised steel angle flanges shall be attached to the casing.

Internal splitters shall be constructed from profiled galvanised steel sheet which contains absorption acoustic material. The absorption material shall be incombustible and shall incorporate a 40% free area (electro-galvanised) expanded metal facing to prevent erosion of fibrous particles.

Cylindrical attenuators shall be of similar construction to the cased splitter type and, where higher insertion losses are needed, axially-mounted acoustic pods shall be fitted.

Attenuators shall be lined with a transparent polyester film not less than 0.025 mm thick to prevent absorption of dirt and contaminants.

Mechanical equipment shall be mounted upon anti-vibration mountings so that the transmission of dynamic forces to the building structure shall be attenuated by not less than 90% for all possible equipment operating speeds. The mounting types shall be either rubber in shear or steel spring.

Mechanical equipment shall be provided with flexible connection. The flexible connectors shall provide maximum structural isolation between the mechanical equipment and the distribution pipework or ductwork. Flexible connectors shall be as near to the mechanical equipment as possible.

3.3 Telephone System Plant

3.3.1 General

The Contractor shall furnish all materials, labors and services required for the installation of a complete private telephone system for the job site(s) as specified herein.

Approvals on all items included in this section must be obtained from the local telephone network Administrator and the Engineer, before supply of any item.

The Contractor to arrange with local telephone network Administrator to ensure the completion of the telephone services for each of the job sites. This shall include but not limited to liaison with the local telephone network Administrator to carry out inspection for the whole telephone installations.

3.3.2 System Description

The system shall comprise an Electronic, Private Automatic Branch Exchange (EPABX) with a Main Distribution Frame (MDF) equipped with power supply equipment and UPS of 4 hours full autonomy.

The telephone system installations shall be complete with all wiring, conduits, telephone junction boxes (TJB), outlets and telephone sets.

3.3.3 Regulations And Standards

All equipment and installations thereof are to be in new standard material in accordance with the relevant national and local codes and regulations.

3.3.4 Manufacturer

All major items of equipment are to be the product of one manufacturer, where practical, to ensure a unified quality and comparable styling and appearance.

3.3.5 System Performance and Facilities

3.3.5.1 System Function

System is to provide a means of intercommunication within the different parts in each of the waterworks sites as well as distribution of the incoming and outgoing telephone calls.

3.3.5.2 System Function

The system features shall include the following:

1. Extension-to-Extension Calls

   Extension-to-extension calls are to be directly made by dialing the other extension number without operator assistance.

2. Direct Outward Dialing (DOD)

Non-restricted and semi-restricted extensions are to be able to gain access to lines without operator assistance by dialing an access code and then dial the exchange number.

3. Direct Inward Dialing (DID)

   External callers can reach extensions by dialing the exchange and the extension numbers without the operator assistance.

4. Camp-On-Busy

   If an extension called is busy, the caller can dial a digit and hang up and be called back when the busy extension becomes idle.

5. Call Forward

   Any extension is to be able to have all calls to his extension automatically forwarded to any other extension.

6. Call Hold

   Any extension can hold a call on his extension while calling a third party. Extension is to be able to confer privately with the third party, recalls the first party thus, establishing a three-party conversation or transfer the first party to the third party.

7. Call Pick-Up

   Any extension in an assigned extension group is to be able to pick-up and answer an incoming call to any other extension within the group.

8. Executive Override

   Selected extensions are to be able to cut into a busy extension following a warning tone to the talking parties.

3.3.5.3 Equipment And Materials

1. Type

   EPABX is to be fully electronic, time-division, switching-based, stored program controlled and designed to support all types or key telephone sets.

2. Characteristics

   EPABX shall have the following characteristics:

   Operator's Console: 1

   Operating Temperature: 0 - 50 C

   Relative Humidity: 60 - 100%

3. Housing

   All exchange components are to be grouped in a modular, totally enclosed, sheet metal cabinet with lockable front access door. Cabinet is to be dust and insect proof. Ventilation is to be provided as required for the specified ambient conditions.

4. Power Supply Equipment

   Mains-operated power supply comprising rectifier, charger and batteries are to supply continuous dc power at the specified voltage to the EPABX. Batteries are to provide a minimum of four hours of continuous operation without loss of system functions or reduction in the system capacity after power supply failure.

3.3.6 Operator's Console

The console shall be desktop; compact type equipped with the necessary controls and displays to provide all services specified herein and verify full control of the system operation.

1. Terminals

   All internal and external lines are to be connected by means of high quality and reliable quick-clip connectors. No soldering or wire wrapping will be allowed.

   Cables are to be arranged and guided in cable positioning slots.

2. Numbering

   Terminals are to be identified by numbered tags corresponding to the respective lines or extensions. The Contractor shall submit proposed numbering scheme for prior approval by the Engineer.

3. Protection

   All trunks are to be fully protected by a set of plug-ins, gas discharge tube over-voltage protectors, fuse ring for thermal protection against prolonged mains contact and rated fuses for over-current protection. Frame earthing is to be provided and interconnected to the earthing system.

3.3.7 Telephone Cables

Cables are to be two-pair or multi-pair, polyethylene insulated, tinned solid copper conductors, twisted into pairs, color coded, with wrapping of aluminum polyester tape and PVC sheath of gray color. Minimum diameter of the conductor shall be 0.65 mm for multi-pair cables and 0.6 mm for two-pair cables.

3.3.8 Optical Fiber Cables

Optical fibers cables shall be multi-mode, graded index optical fibers with nominal 62.5/125 µm core/cladding diameter.

Fibers shall comply with ANSI/EIA/TIA 592-AAAA (Ref. B1.18) and also with ANSI/EIA/TIA 568A Paragraph 12.5.1 on mechanical terminations.

Outdoor optical fibers shall be used to connect MCC buildings to the main distribution frame.

Outdoor optical fibers shall comply with the same specifications; however, cables shall also be steel jacketed, jelly filled, rodent proof specifically made for outdoor applications, with 12 strands.

Optical fibers shall meet the graded-index multi-mode performance specified in following table.

Graded-Index 62.5/125 µm Multi-mode Cable Characteristics

	850 nm	**1300 nm**
Attenuation – dB/km	3.75	1.5
Bandwidth – MHz. km	160	500

Attenuation shall be measured in accordance with EIA fiber optic test procedure ANSI/EIA/TIA 455-46, 61, or 53 (Ref. B1.39). Information transmission capacity shall be measured in accordance with the ANSI/EIA/TIA 455-51, or 30 (Ref. B1.39)

Mechanical and environment specifications for indoor fiber optical cables shall be in accordance with ANSI/ICEA S-83-569 (Ref. B1.40). Outdoor fiber optic cables shall be in accordance with Bellcore TR-TSY-000020 (Ref. B1.36).

3.3.9 Patch Panels

Patch panels shall be type RJ45, 16 port, 1U type in rows of three with extension possible of up to six patch panels.

Patch panels shall be housed inside racking system (19” preferred) cabinets with hinged doors on either sides and lockable front doors.

Ventilation slots shall be provided in both sides.

Rack size shall suit patch panels.

3.3.10 Patch Cords / Line Cords

Patch cords, shall be 2 meters long with adapters at both ends suitable for connection to RJ45 16 port IU patch panels.

Patch cords shall be Category 5 and be flexible enough to bend without loosing any performance.

Patch cords shall be the flexible stranded type.

Line cords shall have the same specifications as patch cords, however these shall be the solid type, used at wall outlets to connect computers or terminals to distribution cabling systems.

Cables shall comply with the performance data specified in the following Table.

Specifications for Category 5 solid/stranded line cords or patch cords

Frequency (MHz)	Attenuation (Max. dB/305 m)	Next (Min Loss dB/305 m)
1.00	6.80	62.0
4.00	14.0	53.0
10.0	22.4	47.0
16.0	28.3	44.0
20.0	31.7	42.0
25.0	35.9	41.0
31.25	40.9	40.0
62.5	59.3	35.0
100.0	76.1	32.0

3.3.11 Outlets

These shall be twin outlet type RJ45 to EN 62368-1 having white molded plastic plates with black shutters for computer outlets and white shutters for telephone outlets.

Outlets shall conform to the following specifications:

1. Attenuation (dB): <-0.12.
2. Return loss (dB): <-21.54.
3. Bulk resistance (milli-ohm): 21.85.
4. Voltage rating: >1050 Vdc for 1 minute.

3.3.12 Telephone Outlets

Outlets are to be cord-grip outlet cover and setscrew terminal block inside box, fixed mounted. Cover plates are to be as other power socket outlets and switches and complying with the building furnishing.

3.3.13 Telephone Sets

3.3.13.1 Type

Telephone sets shall be desk or wall mounted type as shown on the drawings, provided with the necessary keypad. Telephone set construction is to be shock-resistant molded plastic of attractive design and color. Design and color are to be subject to the Engineer's approval. Telephone set is to be dust and insect tight with bell and adjustable volume control.

Telephone sets shall be with digital programmable facilities to comprise in addition to the standard keypad, a set of programmable function keys, alphanumeric LCD display, push buttons and associated LED's as well as a memory with a minimum of ten (10) telephone numbers. Selection of number of programmable telephone sets is to be subject to the Engineer's instructions.

3.3.13.2 Connectors and Cords

Telephone sets are to have lock-in plug-ended cords for connecting handset to the telephone set base and for connecting base to the wall outlet. Cord is to be of not less than three (3) meters long.

3.3.14 Field and Installation Works

3.3.14.1 Installation

All equipment shall be installed in accordance with the manufacturer's recommendations and in coordination with other trades on site. The Contractor to consider local regulations during installations.

3.3.14.2 Cables

Cables are to be run inside heavy gauge PVC conduits with a diameter of 25mm, concealed in walls or under floors.

Outdoor telephone cables shall be installed inside UPVC conduits with a diameter of 90mm, with the required hand holes and inspection chambers.

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SECTION VII – F: TECHNICAL SPECIFICATIONS: MECHANICAL AND ELECTRICAL WORKS

SECTION 11220

VERTICAL SHAFT MIXERS

1 GENERAL

1.1 Work Included

1.1.1 Scope of Supply

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of vertical shaft mixers equipment, including but not limited to:

a) Blade paddles,
b) Driving units,
c) Pre-embedded parts

The pre-embedded parts (steel plates, continuous sections...) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.

1. Embedded parts

Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

The embedded parts (anchors, support parts...) shall be supplied and installed by the Contractor under the present section.

Concreting of the embedded parts shall be covered by Civil Works Section.

2. Covers above the slots shall be provided by the Contractor.

1.2 Related Work

1.2.1 Supplies And Works Included Under This Section Shall Comply With:

A. Part 2 – A: General requirements;
B. Section 01010 - Corrosion protection;
C. Section 01020 - Basic mechanical requirements;
D. Section 01030 - Basic electrical requirements;

1.2.2 Works Under This Section Shall Be Co-Ordinated With:

A. Concrete works covered by the Civil Works Section;
B. Electrical works covered by the Electrical Equipment Section;
C. Section 17200 – SCADA System requirements;

1.3 System Description, Characteristics and Operating Conditions

1.3.1 Operating Conditions

We distinguish in between mixers used for the preparation of the reagents, mixers used for mixing water with reagents and slow agitation mixers which are used in flocculation basins.

The characteristics are detailed in the performance specifications.

Moreover, the Contractor shall provide characteristics of the proposed equipment in the Schedules of Particular:

- Circulation speed of the fluids,
- Rotation speed,
- Absorbed power,
- Helix diameter and speed,
- Weight of the assembly and each equipment

1.3.2 Control and Monitoring

The operation mode of the mixers should have both:

1. Manual control and PLC automatic control.
2. Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up close to the mixing chambers area. It will be IP 55 protected.

The box will be composed at least of the following controls and instructions, for each equipment:

3. Manual / auto commutator
4. Lighted button “ON”
5. Lighted button “OFF”
6. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way this equipment will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the mixers, namely:

7. The way water level in mixing chambers will be maintained constant regardless to the influent flow rate.

   Moreover, the following detectors shall be installed and connected to the PLC:

8. High and low levels detection soundings in chambers.
9. Malfunctions and alarms.

1.3.3 Materials

1. Helix, blades – paddles, vertical shaft axis, mountling steel frame: in stainless steel 316L or inert materials
2. Motor casing: in stainless steel 316L or cast iron with epoxy.
3. Secondary gear: 1.521 alloy steel.
4. Fixing and fastening: in stainless steel 316L

1.4 Quality Assurance

1.4.1 Codes And Standards

1. GB50231-98 General Specification for Construction and Inspection of Mechanical Equipment Installation Engineering
2. SZ-06-99 Quality Inspection and Assessment Standard for Mechanical and Electrical Equipment Installation of Drainage Engineering
3. GB50235-93 Construction and Inspection Specification for Industrial Metal Pipe Installation

4. Manufactory Technical Manual for Grit chamber facilities Installation

1.4.2 Shop Tests and Inspection

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
   a) The seals and the embedded parts shall be presented separately and unpainted for checking.
   b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

   a) Welds:

Refer to Section 01020.

1.5 Submittals

The supplier should submit the following documents (non-exhaustive list):

1. Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…
2. Detailed performance specification of equipment and drawings of all parts
3. Hydraulic and process detailed calculation notes justifying that design criteria are respected.
4. Installation, maintenance and operation manuals with requirements of accuracy
5. Manufacture and quality assurance measures
6. Protective coating list of all parts
7. Commissioning tests list.
8. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
9. Internal wiring diagrams and control principle drawing of control box.
10. Weight and material of each component.

1.6 Guarantee

1.6.1 Performances

The type of blade-paddles shall be decided by the supplier, with a proper rotary velocity efficient to allow either coagulation or flocculation or just an efficient mixing of the reagent.

1.6.2 Dimension Tolerances

1. Tolerances of the mixers inner assembling before installation (blade paddles, hollow shaft, driving device) shall be conform to the manufacturer instructions.
2. After installation, the deviation of the plane position of the driving axis shall be less than ± 5 mm. The verticality of this shaft shall be less than 1/1000.
3. The elevation deviation of paddles shall not exceed ± 5 mm.

2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1 Fabrication

2.1.1 Paddles and Axis

The agitators have a vertical axis and, depending on their use, may be fitted with a geared motor

The agitators operate continuously.

The materials used must take account of the very aggressive quality of the raw water. The Contractor must be fully aware of this quality. The Contractor shall propose the most suitable material for each component of the agitators.

The end stops shall be protected against any water infiltration occurring as a result of failure of the mechanical seals.

It must be easy to dismantle the various components.

The shaft shall be fitted with a casing made of Stellite or any other metal of sufficient hardness, which withstands corrosion and friction passing through the mechanical seals.

The bearing shall be of the grease-lubricated sealed ball bearing type.

The seals shall be mechanical.

The Contractor shall submit a detailed note describing the lubrication and greasing system that he proposes.

2.1.2 Motor and Gear Head

The gear reducer motor shall fit with:

- Working outdoors,
- Working hours: 24 hours per day
- Protection grade IP55,
- Isolation class E
- 230V or 400 V,
- 3 phases,
- 50Hz,
- Rated power 10% higher than maximum actual power.

The service life of the convolution bearing for supporting the impellers shall be 20 years as a minimum. The bearings of reducer shall be well lubricated with working duration no less than 100,000 hours. The gears designed should comply with ISO or equivalent standard, with servo ratio no less than 2.0.

All fixing and fastening items will be made of stainless steel 304L and provided by the Contractor.

2.2 Handling

The Contractor shall design and provide a mobile handling device with hoist and chain able to supply each mixer.

They will be in accordance with specifications of section 16000- Conveying systems.

They shall allow the gathering of equipment in a common assembling area.

2.3 Spare Parts and Special Tools

1. The Contractor shall specify and supply the special tools required for equipment maintenance and for 2 years of operation.
2. The Contractor shall supply 1 set of each of the following spare parts:
   a) axis,
   b) paddles,
   c) gear head
   d) gear box

3 EXECUTION

3.1 Inspection Before Erection

1. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
2. The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2 Field Quality Control

3.2.1 Inspections Before and After Concreting

1. The following inspections shall be carried out before and after concreting:
   a) Holes position
   b) Flatness, verticality, horizontality of the embedded parts,
2. Erection tolerances:

Refer to Section 01020 and paragraph 1.6.2.

3.2.2 Dry Tests

1. Examination of paintwork.
2. Machine must run for two hours without water and without any noticeable problem (noise, axial position…).

3.2.3 Commissioning Tests

1. Examination of paintwork.
2. Checking of operation parameters (rotation speed), for each agitator tested individually.
3. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The water level shall remain nearly constant during these 24 hours testing operations (difference shall be less than 10cm).
4. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.
5. If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.

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SECTION 11221

SUBMERSIBLE HORIZONTAL SHAFT MIXERS

1 GENERAL

1.1 Work Included

1.1.1 Scope of Supply

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of submersible horizontal shaft mixers equipment, including but not limited to:

1. Blade paddles,
2. Driving units,
3. Pre-embedded parts

   The pre-embedded parts (steel plates, continuous sections, ...) to which will be attached the adjustment rods of the permanent embedded parts, shall be supplied, fitted and anchored in the primary concrete under Civil Works Section as will be shown on the civil construction drawings.
4. Embedded parts

   Embedded parts are steel parts anchored either in the secondary concrete or primary concrete and which may be subject to operating loads.

   The embedded parts (anchors, support parts, ...) shall be supplied and installed by the Contractor under the present section.

   Concreting of the embedded parts shall be covered by Civil Works Section.
5. Covers above the slots shall be provided by the Contractor.

1.2 Related Work

1.2.1 Supplies and Works Included Under This Section Shall Comply With:

A. Part 2 – A: General Requirements
B. Section 01010 - Corrosion protection;
C. Section 01020 - Basic mechanical requirements;
D. Section 01030 - Basic electrical requirements;

1.2.2 Works Under This Section Shall Be Co-Ordinated With:

A. Concrete works covered by the Civil Works Contract;
B. Electrical works covered by the Electrical Equipment Section;
C. Section 17100 – SCADA System Requirements;

1.3 System Description, Characteristics and Operating Conditions

1.3.1 Operating Conditions

Submersible horizontal shaft agitators are used for circulating the fluids in the basins, putting them in suspension and creating currents in them.

The agitators may be adjusted horizontally, and have self-cleaning paddles. The agitators are fixed to guide rails and can be handled using mobile cranes fixed to the technical walkways.

The characteristics are detailed in the performance specifications.

Moreover, the Contractor shall provide characteristics of the proposed equipment in the Schedules of Particular:

- Circulation speed of the fluids,
- Rotation speed,
- Absorbed power,
- Helix diameter and speed,
- Weight of the assembly and each equipment

1.3.2 Main Characteristics

a) All mixers shall be driven by electric motors in accordance with the requirements of the electrical specifications.
b) The direction of rotation of all the mixers shall be clockwise when viewed from the motor end of the mixer set assembly.
c) All mixers of same type shall be identical in design and construction in all respects including performance, parts, mountings, connecting flange dimensions and materials.
d) The mixer rotating assembly design shall be such that the first critical speed of the mixer with its motor and the transmission assembly, when running as one system, is at least 150 percent of the maximum operating speed of the mixer.
e) Each component casting of the mixer body shall have a wall thickness of 10mm minimum over and above that required to meet the strength requirements, to compensate for the corrosive and abrasive action of the sewage.
f) The mixers shall be capable to work for long periods continuously without cleaning or attention and special precautions shall be taken to avoid wear on working surfaces dues to grit.

1.3.3 Control and Monitoring

The operation mode of the mixers should have both:

1. Manual control and PLC automatic control.
2. Local control and distance control.

A local control box, including a manual emergency stop button, shall be set up close to the mixing chambers area. It will be IP 55 protected.

The box will be composed at least of the following controls and instructions, for each equipment:

3. Manual / auto commutator
4. Lighted button “ON”
5. Lighted button “OFF”
6. Defaults presentation.

The Contractor shall provide a detailed document explaining the control and regulation system he wants to install, concerning both machines control and the way this equipment will be connected to the general computer. He shall particularly describe the automatic operation principle he wants to install for the mixers, namely:

7. The way water level in mixing chambers will be maintained constant regardless to the influent flow rate.

   Moreover, the following detectors shall be installed and connected to the PLC:

8. High and low levels detection soundings in chambers.

9. Malfunctions and alarms.

1.3.4 Materials

1. Agitator paddle: AISI 316L or inert materials
2. Motor casing: AISI 316L or cast iron with epoxy.
3. Secondary gear: 1.521 alloy steel.
4. Fixing and fastening: AISI 316L

1.4 Quality Assurance

1.4.1 Codes and Standards

A. GB50231-98 General Specification for Construction and Inspection of Mechanical Equipment Installation Engineering
B. SZ-06-99 Quality Inspection and Assessment Standard for Mechanical and Electrical Equipment Installation of Drainage Engineering
C. GB50235-93 Construction and Inspection Specification for Industrial Metal Pipe Installation
D. Manufactory Technical Manual for Grit chamber facilities Installation

1.4.2 Shop Tests and Inspection

A. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
B. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
C. Workshop inspections and tests:

a) The seals and the embedded parts shall be presented separately and unpainted for checking.
b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

c) Welds:

Refer to Section 01020.

1.5 Submittals

The supplier should submit the following documents (non-exhaustive list):

1. Detailed Ichnography and section diagram and specification for equipment, showing all functional dimensions and space necessary for maintenance, operation and installation…
2. Detailed performance specification of equipment and drawings of all parts
3. Hydraulic and process detailed calculation notes justifying that design criteria are respected.
4. Installation, maintenance and operation manuals with requirements of accuracy
5. Manufacture and quality assurance measures
6. Protective coating list of all parts
7. Commissioning tests list.
8. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
9. Internal wiring diagrams and control principle drawing of control box
10. Weight and material of each component

1.6 Guarantee

1.6.1 Performances

The type of blade-paddles shall be decided by the supplier, with a proper rotary velocity efficient to create currents of the fluids and suspend matter.

1.6.2 Dimension Tolerances

A. Tolerances of the mixers inner assembling before installation (blade paddles, hollow shaft, driving device) shall be conform to the manufacturer instructions.
B. After installation, the deviation of the plane position of the driving axis shall be less than □ 5 mm. The verticality of this shaft shall be less than 1/1000.
C. The elevation deviation of paddles shall not exceed ± 5 mm.

2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1 Fabrication

2.1.1 Paddles and Axis

The materials used must take account of the quality of the raw water. The Contractor must be fully aware of this quality. The Contractor shall propose the most suitable material for each component of the agitators.

The end stops shall be protected against any water infiltration occurring as a result of failure of the mechanical seals.

It must be easy to dismantle the various components.

The shaft shall be made of stainless steel in order to prevent corrosion of the parts in contact with the water being treated. It shall be fitted with a casing made of stellite or any other metal of sufficient hardness, which withstands corrosion and friction in the mechanical seals.

The bearing shall be of the grease-lubricated sealed ball bearing type.

The seals shall be mechanical. The shaft shall be sealed using two tight mechanical seals fitted in tandem regardless of the direction of rotation.

The Contractor shall submit a detailed note describing the lubrication and greasing system that he proposes.

2.1.2 Motor and Gear Head

The gear reducer motor shall fit with:

- Working outdoors,
- Working hours: 24 hours per day
- Protection grade IP68,
- Isolation class F,
- 400 V,
- 3 phases,
- 50Hz,
- Rated power 10% higher than maximum actual power.

The service life of the convolution bearing for supporting the impellers shall be 20 years as a minimum. The bearings of reducer shall be well lubricated with working duration no less than

100,000 hours. The gears designed should comply with ISO or equivalent standard, with servo ratio no less than 2.0.

All fixing and fastening items will be made of stainless steel 304L and provided by the Contractor.

2.2 Handling

The Contractor will provide a monorail hoist and a chain able to supply each mixer.

They will be in accordance with specifications of section 16000- Conveying systems.

They shall allow the gathering of equipment in a common assembling area.

2.3 Spare Parts and Special Tools

A. The Contractor shall specify and supply the special tools required for equipment maintenance and for 2 years of operation.
B. The Contractor shall supply 1 set of each of the following spare parts:

a) axis,
b) paddles,
c) gear head
d) gear box

3 EXECUTION

3.1 Inspection Before Erection

A. The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
B. The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2 Field Quality Control

3.2.1 Inspections Before and After Concreting

A. The following inspections shall be carried out before and after concreting:

a) Holes position
b) Flatness, verticality, horizontality of the embedded parts,

B. Erection tolerances:

Refer to Section 01020 and paragraph 1.6.2.

3.2.2 Dry Tests

1. Examination of paintwork.

   Machine must run for two hours without water and without any noticeable problem (noise, axial position…).

3.2.3 Commissioning Tests

1. Examination of paintwork.
2. Checking of operation parameters (rotation speed, flow speed, absorbed power), for each agitator tested individually.
3. For each agitator, checking of operation conditions for nominal flow and during 24 hours. The water level shall remain nearly constant during these 24 hours testing operations (difference shall be less than 10cm).

4. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.

If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached.

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SECTION 11 230

LAMELLAS PLATES

1 GENERAL

1.1 Work Included

This section of the specifications covers the Lamellas of the primary sedimentation tanks.

The supply shall include the following main items:

1. Lamellas,
2. Lamellas assembly system,
3. Anchoring and Support system.
4. The special tools and the spare parts.

1.2 Related Works

Supplies and works included under this section shall comply with the requirements of the following:

1. Section 01010 – Corrosion Protection
2. Section 01020 - Basic mechanical requirements

Work under this section shall be coordinated with:

1. Civil Engineering works and Building works;

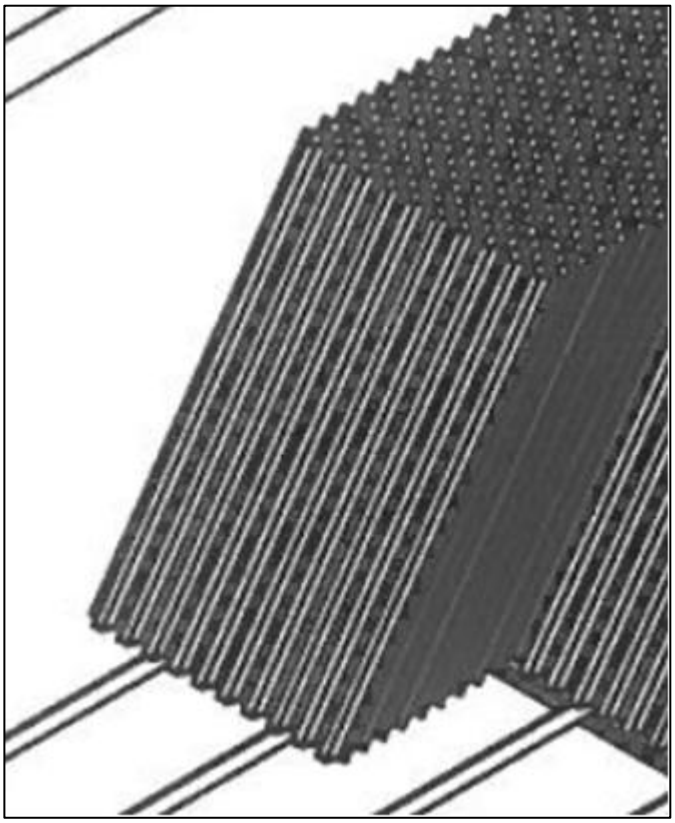
1.3 Description

1.3.1 Lamellas

The lamellas shall be installed in primary sedimentation tanks. The lamellas shall present the following characteristics:

Type:	to be defined by the Contractor
Location:	Primary sedimentation
Angle	60 degrees
Plate Material:	Super high impact Polystyrene type: Thermoplastics ISO 2897-PS-I,G,093-03-07-18 or ISO 2897-PS-I,G,093-03-10-18
The plates shall be assembled with 304 SS staples on site.	

Each lamella shall be cut such that when installed at a 60 degree angle the bottom and top part of the lamella plate shall be completely horizontal.



1.3.2 Support System

The support system shall support the entire weight of the plates plus 50%, in order to account for organic material collected on the plates when the tank is emptied for maintenance.

The support system shall be made of SS 304, and the anchoring system shall meet the corrosion protection requirements of Section 01010.

1.4 Quality Assurance

1.4.1 Design Criteria

A) Refer to Section 01020.

The lamellas shall be designed to withstand without damage an MCE (maximum credible earthquake).

1.4.2 Source Quality Control

1. Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
2. Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
3. Workshop inspections and tests:
   a) At the end of manufacture, the lamellar plates shall be presented, for checking
   a) Welds:

Refer to Section 01020.

1.5 Submittals

Refer to Section 01 000 -General requirements

2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1 Manufacture

The tolerance on the dimension of each plate delivered on site shall be +/- 0.1%.

The one site assembly of the bee's nest pattern shall be performed by the contractor immediately before installation on the support system in the tank. Blocks of 6 to 8 plates stapled together shall be prepared outside of the tank, then installed on the support system, at which point the blocks shall be stapled together.

2.2 Transport and Storage

Plates shall be transported and stored at temperatures between -10 ºC and + 60 ºC.

2.3 Special Tools and Spare Parts

The Contractor shall supply the following tools and spare parts:

1. 100 plates, unwelded
2. Air powered stapler

3 EXECUTION

3.1 Inspection Before Erection

A) The Contractor shall check the dimensions of the delivered plates prior to welding.
B) The Engineer shall check the plates prior to their assembly: Any plate showing signs of bulking due to heat above 60oC during transport and storage shall be rejected by the Engineer.

3.2 Field Quality Control

A) The Contractor shall check the setting and alignment of support system prior to fixing the welded plates
B) The Contractor shall check the dimensions and the regularity of the pattern of the welded plates prior to their fixing on the support system.

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SECTION 11351

HIGH PRESSURE CENTRIFUGE FOR SLUDGE

1 GENERAL

1.1 Scope of Work

A. Furnish all labor, materials, equipment and incidentals required and install ready for operation high pressure centrifuge for sludge thickening and dewatering of raw sludge coming directly from the clarifier settling tanks with 5-8g/l concentration as shown on the Drawings and as specified herein.
B. Related Sections:
   1. 11305: Sewage Treatment Plant Mechanical Process and Equipment.

1.2 Submittals

A. Submit to the Engineer, technical data and shop drawings showing details of fabrication and erection of all materials and equipment furnished under this Section.
B. Operating and maintenance instructions shall be furnished to the Engineer.

1.3 Reference Standards

A. Anti-Friction Bearing Manufacturers Association (AFBMA)
B. American Gear Manufacturers Association (AGMA)
C. National Electrical Manufacturers Association (NEMA)
D. DIN Standards.

1.4 Quality Assurance

A. All equipment shall be of the highest quality throughout, designed for a long life of trouble-free operation. All of the centrifuge equipment shall be furnished by a single manufacturer and guaranteed for process and mechanical performance by the original equipment manufacturer. Equipment supplied shall conform to all aspects of the specification.

1.5 System Description

A. High pressure Centrifuge for Sludge Dewatering:
   1. The centrifugal solid bowl horizontal decanter shall be of continuous feeding, continuous operation, and counter flow horizontal spiral type. Centrifugal dewatering decanters including the control cabinet of sludge dewatering system, and all the required accessories, fastening pieces, and spare parts and etc.
   2. The decanter centrifuge shall be designed for the double duty of sludge thickening and sludge dewatering within the same unit.
   3. Typical average infeed sludge is raw secondary sludge from the final clarifier of an Oxi-ditch plant with SRT of 10-15 days. The feed solids concentration (DS) is about 5 to 8 g/l. Feed volatile solids content 62-68%.
   4. Water content of dewatered sludge cake shall be minimum ≥ 20 %.
   5. Nominal rotary speed shall not exceed 3500 rpm Maximum speed 4000 rpm.
   6. Centrifuge shall be of high-performance scroll with an acceleration of (>3000 g). The parameters of bowl speed (efficiency of solid/liquid separation, relative scroll speed

(residence time, dryness), pond depth (clarification), can be adjusted independently of one another, and with high accuracy.

7. The centrifuge shall have a speed adjustment by frequency converters.
8. The centrifuge material shall be stainless steel AISI 304.
9. The centrifugal decanter shall include the rotary drum and internal spiral-feeding unit. Under the condition of the rotary speed larger than the rotary drum the spiral feeding unit shall push the solid matter through the cylindrical part of the rotary drum and to the conical part, then discharge it from the discharge port.
10. The discharge port shall be protected by the Tungsten carbide sleeve. In order to prevent the inside of equipment from wearing, the inner buffering plate shall not be equipped.
11. The rotary part of the centrifugal decanter shall be supported by two main bearings. The main bearings shall be ball bearings or roller bearings lubricated by oil.
12. The bearings shall be installed on the housing of the centrifugal decanter. After the bearings are lubricated with the saponification lithium grease once, the permanent lubrication function shall be maintained. The design longevity of bearings shall be up to 100,000 hours under L10 standard.
13. The rotary unit and bearings shall be fixed on a specially designed and very firm carbon steel support frame with the vibration damper function. The housing of the equipment shall provide the best protection for the equipment and shall seal the smelly gas.
14. The driving system of the rotary drum shall include one motor and one belt driving system. The V-belt driving system shall bear the full load of equipment, and he total start-up torque of the system. The main driving motor shall be of insulation F, and B grade of temperature rise, 3600rpm. The spiral driving system shall include one set of motor and one frequency converter, rotational speed, and driven by the double transmission gearbox. The circular geared pressure-reduced unit driven by the double speed gearbox shall be equipped for the centrifugal decanter, to result in the speed difference between the rotary drum and the screw.
15. Under the conditions that the total equipment runs emptily and the feeding inlet and the discharge port are closed; the test shall be carried out in the manufacturer. The average noise at the place of one meter to the decanter shall not exceed 86dBA, and the vibration shall not exceed 4.5mm/s.
16. The rotary drum shall be made by the centrifugal casting of stainless steel 304L. The spiral body and vane of the feeding screw are made of stainless steel 304L, and the position of the spiral vane pushing the sludge shall be coated with tungsten carbide. Except O-rings, sealing washers, and wearing-proof material, all rotary components of the centrifugal decanter in contact with the sludge shall be made of the materials of not lower than stainless steel 316. The O-rings and sealing washers shall be made of synthetic rubber. The support frame and the housing shall be made of carbon steel.
17. Each set of centrifugal units shall be equipped with one set of control cabinet with degree of protection of IP55, and stainless-steel casing. It will provide power supply, control, indication, alarm for the sludge crushers, sludge feeding pump, sludge flow-meter, the flocculent preparation and dilution unit, the centrifugal dewatering unit, the sludge cake conveyor, etc. to ensure the safe operation of the sludge dewatering system.
18. Centrifuges shall include the outlet hopper which shall feed the screw conveyor. The hopper must be designed to the local conditions.

    a) Driving system:

        1. Bowl speed + variable scroll speed using frequency inverters.

2. Main Motor +Frequency converter; secondary Motor (generator) + frequency convertor.

b) Motor characteristics:

1. Asynchronous motors IEC 380V-50HZ
2. EFF2- PROTECTION IP 55
3. CLASS F INSULATION
4. Drive motor rating 45 KW

19. Wear protection: scroll (replaceable tungsten carbide tiles);
20. Scroll feed chamber and bowl diffuser –ceramic nozzles. (16000 hrs /2years)
21. Materials: wetted parts 304L stainless steel

1.6 Maintenance

A. Tools and Spare Parts:

1. Special tools, required for normal operation and maintenance, shall be furnished with the equipment.
2. The supplier shall furnish all spare parts that are needed.

2 PRODUCTS

2.1 General

A. The equipment specified herein is intended to be standard mixing equipment of proven ability as manufactured by reputable concerns having at least 10 years' experience in the production of such equipment. The equipment shall be designed, constructed, and installed in accordance with the best practice and methods, and shall operate satisfactorily when installed as shown on the Drawings.
B. All parts shall be so designed and proportioned as to have liberal strength, stability and stiffness and to be especially adapted for the work to be done. Ample room and facilities shall be provided for inspection, repairs and adjustment.
C. The unit shall be of the best quality on the market. ANDRITZ make, ALFALAVAL or equivalent.

3 EXECUTION

3.1 Installation

A. Installation shall be in strict accordance with the manufacturer's recommendations. Stainless steel anchor bolts shall be set in accordance with certified prints furnished by the manufacturer.

3.2 Inspection and Testing

A. After all the equipment has been completely assembled, painted and approved by the manufacturer's factory representative and after approval by the Engineer, the equipment shall be placed in operation under the supervision of a factory representative.
B. The Engineer may require any and all tests of the equipment which in his opinion may be necessary to demonstrate to his satisfaction that the equipment is correctly installed and is in proper operating condition and free from defects or faults of any kind. The Contractor shall

furnish all labor and incidentals required to conduct such tests and to correct to the full satisfaction of the Engineer any and all defects or deficiencies noted.

C. A 7-day continuous operation period for mixers shall be required before acceptance.

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SECTION 11361

GRAVITY SLUDGE THICKNERS (PICKET FENCE TYPE)

1 Sludge Thickeners Mechanism

1.1 Gravity Thickeners

1. Circular (radial), fixed bridge, central drive type picket fence, collecting effectively with proper circumferential speed, a sludge thickener shall be provided. The thickener shall be rugged and robust in design and shall be provided with high-capacity drive head and induction motor having high torque rating, centrally located, with positive sludge raking by means of one or more raking arms. Both the raking arms should have scraper blades fitted at the bottom, so that the sludge from scraper blades is pushed to the sump on every rotation.
2. The circular reinforced concrete thickeners tapering at bottom shall be provided for thickening process. The sludge laden suspension from Waste water balancing Tank shall be fed to thickeners.
3. Design shall be such that the sludge can become compacted and can be extracted from the bottom. Interstitial liquid flows through peripheral weir at top. Tanks shall be deep enough to allow the sludge to settle. At least 50 cm freeboard shall be provided. Provision shall be made to remove the sludge from top if there is a serious risk. Provision shall be made for collection of thickened sludge and pumping it to Centrifuge.
4. A full diameter bridge with central drive shall be provided with: central platform for the installation of the scrapers and their drives and for the local control panel; a radial scraper system with bottom scraper blades, suspended on the bridge.
5. The thickeners shall have a full diameter fixed bridge complete with 1200mm walkway for personnel access to the center, access stairs to ground level and hand railing, a motor driven sludge scraper complete with all necessary controls, delivery pipe work, a stilling well and overflow steel weir plates. Hand railing, walkways, access steps etc. shall be galvanized. Handrails shall be of tubular construction and made of 32NB pipes.
6. The scraping gear shall be supported from the tank base and from a fixed bridge carrying the central electrical drive for the rotating gear. The equipment including driving motor, gears, shafting and scrapers shall be designed for continuous operation and sized for the most arduous operating condition including starting from rest with an accumulation of sludge in the thickeners.
7. The electric motor, gearbox etc., shall be provided with a sunshade.
8. The fixed bridge, hand railing, access steps and the feed well shall be mild steel epoxy painted. The main drive shall be cast Iron construction and shall be enclosed in a dustproof enclosure with oil bath lubrication. All underwater hardware shall be of SS316.
    - ~ Corrosion allowance of 2 mm shall be taken in the structural sections of scraper arm, bridge etc.
    - ~ Structural design calculations shall be submitted for all structures including scraper arm, bridge etc. And also, the calculation for drive head selection including the Torque Rating.
9. V-notch weir in SS 304 construction of size minimum 3mm thick and 200 mm wide shall be provided along the launders for uniform draw-off of the overflow. The weir plate shall be fixed to the launder by means SS304 grade clamping plates and fasteners.
10. Chain and Sprocket arrangement is not acceptable.

11. The hydraulic equipment will consist of the DI inlet pipe (runs along the bridge) to the central feed well of the thickener; sludge draw-off pipe with a manual & Motorized Knife Gate valve (in SS CF8M material of construction) for intermittent operation according to an adjustable timer; a drain pipe with manually operated gate valve for the complete emptying of the unit; a discharge pipe/channel from the peripheral collecting channel to the main channel leading to the Supernatant sump. The sludge thickener mechanism shall be generally in MS epoxy painted construction, suitable for installation in a circular RCC tank and shall include the following:

    ~ Mechanism support beam spanning the diameter of the tank.

    ~ Walkway and handrail from the edge to the center of the tank.

    ~ Drive mechanism with internal gear type.

    ~ Reduction gear box.

    ~ Central shaft with scrapper arm and picket fence.

    ~ Skimmer Scum Baffle and Scum trough.

    ~ Overflow weir:

    ~ Vertical pickets.

    ~ Overload Alarm protection.

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SECTION 11363

ANAEROBIC DIGESTERS AND BIOGAS BOILERS SYSTEMS

1 DIGESTERS

1.1 Sludge Circulation

1.1.1 Gas Injection System (Optional)

1. Gas lances shall be grouped in groups of six. Each group shall be isolated by an electrically (explosion proof) valve.
2. Each lance shall be isolated by a manually operated valve. All groups shall be connected to a gas main ring pipe (SS) equipped with electrical actuated (explosion proof) valve and flame arrestor.
3. Gas lances shall be suspended from the digester roof. Each lance shall be supported from the roof and shall pass through a gas seal tube (SS). Lances shall be removable from the digester for maintenance without interruption of operation.
4. Lances shall extend to a level of approximately 3m above digester floor and consist of:
   - Ductile cast iron gas lance head diameter approx. DN 100 with discharge nozzle approx. 25mm
   - PE, SS suspended flexible lance pipe
   - Flanged isolating valves

1.1.2 Mechanical Mixer – Screw Lift Type

1. Screw lift type sludge mixer shall be of mixing cage including impeller and sludge lifting pipe including all fixings, supports, bearings, etc. All moving parts shall be protected from sludge penetration.
2. Sludge lifting pipe shall be flanged and provided with inlet and outlet bell mouth made of ductile cast iron.
3. The mixing cage shall be equipped with a wound-up impeller with drive shaft extending to the drive motor.
4. The drive motor shall be of explosion proof type, digester roof mounted and provided with a sun protection.

1.2 Scum Removal

1. Water and gas tight scum removal trap shall be manufactured from stainless steel and resist a pressure of 50 mbar.
2. The scum trap shall consist but not be limited to:
   - Scum trap
   - Manual operated quick sluice valves, stainless steel

1.3 Biogas Compressor

1. Gas compressor shall be of Rotary Vane Type with water-cooled oil injection cooling system; single stage with flexibly coupled direct drive.
2. The complete unit shall be mounted on a common base plate/frame with anti-vibration mountings.

3. The unit shall be provided with all required ancillaries e.g. gas intake filter, separators, regulating valves, suction non return valve, safety valve, condensation drain and tank, steel compensators, pressure gauges, cooling system unit with safety thermostat and shall comply to the relevant compressor rules e.g. DIN 1945 / VDE 2045 latest edition.
4. Motor protection class IP55, insulation class F explosion proof.
5. Unit monitoring and control panel with all requisite instrumentation and interfaces to the station PLC.

1.4 Sludge Heat Exchanger

1. The temperature of the sludge in the digesters shall be kept at approximately 360c. Therefore, sludge will be taken from the digesters and pumped though heat exchangers. Hot water gained from biogas generator cooling water system will be utilized for preheating the sludge.
2. The sludge heat exchanger shall be of counter-current, double pipe heat exchange.
3. Sludge and hot water design flow shall in accordance with the sludge and hot water pump capacities.
4. The heat exchanger shall be made of stainless-steel pipes (DIN 2462/2463) bends and with flanged sludge and water connections and be provided with a rack made of carbon steel.

- Materials:
  - Sludge tube Stainless steel AiSi 316 Ti
  - Water tube Stainless steel AiSi 316 L

5. Sludge and hot water connection shall be flanged and be in accordance to DIN 2501, PN 10.
6. The heat exchanger shall be equipped with inlet and outlet shut off valves and thermostats e.g. PT 100 as specified.
7. Sludge velocity shall be in a range of 1 m/s while the hot water velocity shall be in a range of 1.5 m/s.
8. Hot water inlet temperature will be approx. 800C and outlet temperature will be approx. 360C.
9. Sludge inlet temperature will be approx. 300C and outlet temperature approx. 360C.
10. The heat exchanger shall be thermal insulated e.g. glass fiber matting including aluminum cladding.

2 BIOGAS UTILISATION

2.1 Biogas Holder

1. Gas vacuum/surplus pressure safety device shall be designed to avoid vacuum/excessive surplus pressure in the Biogas Holder. The safety devise shall be provided with flanges PN 10 according to DIN 2501.
2. The safety shall comply with the relevant safety regulations.
3. Flame arresters shall be included.
   - Setting range - 20 mbar to + mbar

2.2 Biogas Desulphurization

1. Desulphurization of Biogas shall be by the ferric hydroxide process with automatic regeneration.
   - Hydrogen Sulphur content approx. 2.2 g/Nm^3

2. The unit shall be provided with all required ancillaries and be ready for connection and operation e.g. desulphurization tower – stainless steel 1.4571, thermal insulation including aluminum cladding, service platform and access ladder – galvanized steel, electric chain hoist – ex proof – for material feed, regenerating air feeding system including all valves fittings etc., regenerating air compressor, condensation drain and tank, steel compensators, pressure gauges, and shall comply to the relevant vessel rules, latest edition.
3. Monitoring unit and control panel with all requisite instrumentation and interfaces to the station PLC.
4. Flame arrestors to be part of the supply.
5. A fully automatic, air cooled, air compressor complete with air receiver, shall be installed.
6. Motor protection class IP55, installation class F explosion proof.

2.3 Biogas Boiler

1. Sludge due to be pumped into the digesters will be heated up by means of either injecting steam into the sludge or by heat transfer via heat exchanger. Steam/hot water will be produced by dual fueled boilers.
2. Boilers shall be in accordance with TRD 401, TRD 601 etc. (technical rules steam).
3. Boiler shall be horizontal large water space boiler, fully automatic type complying with the "Technical Rules for Steam Boilers" and for permanent 24h operation.
4. The boiler unit shall be provided with all required ancillaries and be ready for connection and operation, e.g.:
    - Boiler shell, convection heating tubes, flanged nozzles for valves and fittings, inspection holes with covers, burner muffle, boiler support frame, lifting eyes, insulation and cladding, valves for steam supply and feed water, boiler pressure gauge, safety valve, glass water level indicator, drain, blow down valve, flue gas exit connection, etc.
    - Monitoring and control board including for e.g. water level controller, on/off control, water level limiter, pressure limiter and switch, pressure controller and switch.
    - Switchgear cabinet fully equipped and instrumented including main switch, fuses, auxiliary contractors, thermal control, push buttons, signal lamps, timer, boiler and burner monitoring indicator etc.
    - Combined gas and fuel oil burner complying to the relevant VDE rules including combustion air fan, combustion air control, fuel supply system, fuel leakage monitoring system, infinitely variable burner head, electrical ignition system, flame detector and all required valves, pressure gauges, connection parts for valves and fittings including supports, safety equipment etc. fully wired and ready for connection.
    5. Unit monitoring and control panel shall be provided with all requisite instrumentation and interfaces to the station PLC.

2.4 Emergency Cooling System

1. The cooling system shall comprise but not be limited to:
    - Heat exchanger, emergency circuit
    - Circulation pumps
    - Expansion vessel
    - Adjustable throttle
    - Piping, valves

- Fan cooler
- Monitoring and control system
- Terminal boxes

2.4.1 Distribution Sampler

1. Distribution sampler shall be designed for coordinating the flows between heat recovery system and sludge heat exchange.

2.4.2 Local Control Panel

1. Local control panel shall control and monitor all functions of the Digester process.

2.5 Biogas Flare (Hidden Flare Type)

1. Gas burner shall be provided for burning off the surplus gas, and shall have capacity to turn all generated gas quantity. The burner shall be designed for fully automatic, permanent 24 h operation at full capacity.
2. The unit shall be provided with all required ancillaries and be ready for connection and operation e.g. automatic ignition, stand pipe with gas feed tube, electric actuated valves, flame tube, flame tube, flame arrestor of suitable material, monitoring and control board etc.
3. Unit monitoring and control panel Ex. Proof shall be provided with all requisite instrumentation and interfaces to the station PLC.

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SECTION VII – F: TECHNICAL SPECIFICATIONS: MECHANICAL AND ELECTRICAL WORKS

SECTION 11370

POLYMER PREPARATION

1 GENERAL

1.1 Work Included

This section deals with technical requirements for the design, manufacture, delivery, off-loading, erection, testing and commissioning of automatic polymer preparation unit, including but not limited to:

1. Polymer storage,
2. Automatic polymer preparation unit,
3. Polymer injection pumps,
4. Inline dilution,

The equipment shall be complete with all base plates, foundation bolts, and all other items of equipment necessary to make the installation complete and perfect in every detail.

The above listed equipment shall be considered as a package that shall be coordinated and integrated by the manufacturer.

The polymer equipment shall be designed for automatic operation.

1.2 Related Work

Supplies and works included under this section shall comply and be coordinated with all others parts and section of the contract.

1.3 System Description, Characteristics and Operating Conditions

1.3.1 Operating Conditions

1.3.1.1 General

The preparation unit is designed for an automatic functioning as soon as the dewatering units are operating.

The contractor proposes all capacities to guaranty the reliability of dewatering operations.

All motors must be easily reached for maintenance operation.

Inspected panels must be enough sized to make cleaning operations easier.

Overflow and drainage devices must be connected to drain gutter.

A local control panel including all power supply (mixers, screws, solenoid valve, pumps) and automatism is also provided.

1.3.1.2 Automatic Polymer Feeding

Dry polymer shall be fed by mechanical, positive displacement volumetric feeder. Motor shall be variable speed.

The discharge port of the volumetric feeder shall be completely enclosed in a chamber. The polymer/water initial wetting area shall be clearly visible. The acrylic barrel shall prevent inadvertent drifting of airborne polymer dust and protect feeder discharge from environment. The discharge port

shall be fitted with a pneumatically operated valve to isolate dry polymer from the environment between cycles.

Dry polymer shall rely on gravity to transfer from feed device to wetting device. This shall eliminate the need for any type pneumatic conveying system.

1.3.1.3 Dilution Water

Dilution water flow for polymer batching shall be from well service water (6 bars) or in case of poor quality from drinking water supply, equipped with reduced pressure backflow preventer. Drinking water available service pressure is around 1,5 bars. The Contractor foresees the suppression pump to achieve needed service pressure for polymer preparation (at least 3 bars). Dilution water shall be maintained at a constant rate by means of a flow control valve. A differential pressure indicator/switch shall be supplied to display water differential pressure. Low differential pressure switch shall shut down system and energize alarm at Local Control Panel after adjustable time delay. Water flow (on/off) shall be controlled by a solenoid valve with spring to close for fail-safe operation. Dilution water feed shall include rotameter to provide visual indication of flow.

1.3.1.4 Mixers

The Contractor shall provide characteristics of the proposed equipment:

- Circulation speed of the fluids,
- Absorbed power,
- Weight of the assembly and each equipment

1.3.1.5 Pumps

1.3.1.5.1 Pump Duties

Each of the pumps shall be capable of operating continuously without damaging effects. If the Contractor considers that additional measures or controls are necessary to protect the Plant from any long-term damaging effects, then all such equipment and controls shall be provided and shall be deemed to have been included in the contract price. The details shall be submitted with the Tender.

1.3.1.5.2 Pump Suction Ability (NPSHR)

The pump shall be capable of operating satisfactorily in the specified operating range. The pump NPSHR shall be less than the NPSHA under any operating condition at Site to avoid cavitation. If the pump requires any increase of the system head so as to achieve satisfactory operation at any point in the specified operating range, then this shall be clearly stated in the Tender. The method and details of creating the additional system head shall be stated and drawings showing any changes required in the civil layout shall be submitted. Where such requirements affect the hydraulics of the complete system, hydraulic calculations shall be carried out and included in the Tender. If the change implies higher energy cost during operation of plant, then this will be taken into account during tender assessment.

1.3.1.5.3 Pump Rated Speed (NR)

The maximum rated speed of the pumps shall be designed by the Contractor.

1.3.1.5.4 Pump Shaft Power and Pump Efficiency

The pump shaft power characteristics shall be stable within the duty range and shall be non-overloading at the pump operating speed.

1.3.1.5.5 Reverse Rotation Capability

Under shut down conditions, reversal of the pump rotation will take place and the pump, motor and shafting shall be designed accordingly.

1.3.1.6 Post Dilution Assemblies

It shall provide additional dilution required by application. System shall include skid-mounted post-dilution units consisting of a static mixer in a clear PVC housing, rotameter-type flow indicator with

rate-adjusting valve. The post-dilution water flow rate shall be adjustable. Provide rotameters to measure dilution water flow.

1.4 Quality Assurance

1.4.1 Shop Tests and Inspection

A) Inspection and testing of raw materials used in the manufacture of the equipment: the Contractor shall supply certificates of mechanical tests and chemical analysis.
B) Inspection and testing of standard products: the Contractor shall supply certificates of routine tests.
C) Workshop inspections and tests:
    a) The seals and the embedded parts shall be presented separately and unpainted for checking.
    b) The surface appearance of embedded parts shall be examined and their dimensions checked. Rolling, sliding and plate sealing surfaces shall be perfectly flat and smooth.

All dimensions shall be checked.

1.5 Submittals

The supplier should submit the following documents (non exhaustive list):

1. Installation, maintenance and operation manuals with requirements of accuracy
2. Manufacture and quality assurance measures
3. Protective coating list of all parts
4. Commissioning tests list.
5. Assembler details for welding and building connections, foundation requirements and bearing loads for civil structures.
6. Internal wiring diagrams and control principle drawing of control box
7. Weight and material of each component

2 PRODUCTS, COMPONENTS AND SUB-ASSEMBLIES

2.1 Mixers

The mixer shall utilize stainless steel impellers. The mix tank impeller shall be driven by a washdown duty motor coupled with a right-angle gear reducer. The gear reducer and motor shall be mounted on a stainless steel or fiberglass channel crossing the mixing/holding tank. The impeller shall be coupled to the gear reducer.

The impeller diameter shall be as large as possible to fit inside the tank diameter, guaranteeing the most uniform distribution of mixing energy.

The mixer shaft shall be stainless steel with clear PVC sleeve to direct polymer slurry from the wetting device into hollow-bladed impeller.

2.2 Pumps

2.2.1 General

All pumping units shall be supplied as complete pumping systems, including the pump, its driving motor, the drive shaft and couplings, local control panels and all necessary appurtenances (including protection devices, switches, etc.).

Pumps and motors shall be flexible-coupled. That portion of the shaft extending through the mechanical seal (s) shall be equipped with a replaceable sleeve (sealed or positive locked to the shaft) such that the entire shaft need not be replaced when it is scored or worn in this area. Pump shafts shall be designed for a maximum deflection at the shaft seal of 0.05 mm (0.002 in). All couplings, connections, external sealing, etc. shall be weather protected, suitable for outdoor installation.

Pump shafts shall run in ball bearings. The bearings shall be grease-lubricated and shall be contained in dust-proof and moisture-proof housing. The bearings and frame design shall be such that the bearings can be re-lubricated by use of external greasing devices. The pump design shall ensure that the outboard bearing can carry a combined thrust and radial load. Bearings shall be adequately designed to carry all radial and thrust lads through the normal operating range of the pump. Bearings for pumps in continuous operation (or in continuous rotation of operation) shall have an L-10 life of at least 40,000 hours at the operating point.

Mechanical seals, not packing, shall be used for all pumping units. Seals shall be of the type not requiring water sealing or flushing water.

Oil level shall be maintained by a constant level oilier with visible oil supply.

All openings in the pump shall be large enough to permit passage of solids with maximum diameter of 60 mm.

Connections to concrete foundations for all pumps shall be sufficient to withstand a displacing force equal to that developed by an internal pressure equal to three times shut-off head at maximum operating speed.

Pumping units shall be designed to operate without damaging vibration over the entire specified range of flow and head conditions and (where appropriate) over the range of speeds specified.

Major pump components shall be of gray cast iron with smooth surfaces devoid of blow holes or other irregularities. All exposed nuts, bolts and washers shall be of AISI type 304 stainless steel or better. All metal surfaces coming in contact with the pump- age, other than stainless steel or brass shall be protected by a factory-applied spray coating of alkyd primer with oxiranes her paint finish on the exterior of the pump. Sealing design of major pump components shall incorporate metal to metal contact between machined surfaces. Critical mating surfaces where watertight sealing is required shall be machined and fitted with Nitrile or Viton O-rings. Fittings will be of controlled compression of rubber O-rings in two planes and O-rings contact of four sides without the requirement of a specific torque limit.

Neither rectangular sectioned gaskets neither requiring specific torque nor scaling compound shall be considered as equal.

Pumping units shall have no dangerous critical or resonance frequencies. The Contractor shall be responsible for the analysis of critical speeds and the complete mass elastic system, and shall submit calculations in this regard to the Engineer or his representative for approval prior to erection.

Pumping units shall be suitable for connection to No.-Flow shut-off switches, such switches to be supplied with all check valves supplied.

Each unit shall be provided with an adequately designed cooling system. Provisions for external cooling and seal flushing shall be provided. The cooling system shall provide for continuous pump operation in liquid temperature of up to 40°C.

2.2.2 Cable Entry Seal

The Cable entry seal design shall preclude specific torque requirements to insure a watertight and submersible seal. The cable entry shall consist of a single cylindrical elastomer grommet, flanked by washers, all having a close tolerance fit against the cable outside diameter and the entry inside diameter and compressed by the body containing a strain relief function, separate from the function of sealing the cable the assembly shall provide ease of changing the cable. The cable entry junction chamber and motor shall be separated by a terminal board, which shall isolate the interior from

foreign material gaining access through the pump top. Epoxies, silicones, or other secondary sealing systems shall not be considered acceptable.

2.2.3 Motors

The pump motor shall be a squirrel cage induction motor, shell type design, housed in an air-filled watertight chamber. The stator windings and stator leads shall be insulated with moisture resistant Class F insulation rated for 155°C. The stator shall be dipped three times in Class F varnish and shall be heat-shrink fitted into the stator housing. The motor shall be designed for continuous duty handling pumped media of 40°C and capable of up to 15 evenly spaced starts per hour. Thermal switches set to open at 125°C and closed at 70°C shall be embedded in the stator load coils to monitor the temperature of each phase winding. These thermal switches shall be used in conjunction with and supplemental to external motor overload protection and shall be connected to the control panel. The junction chamber containing the terminal board shall be hermetically sealed from the motor by an elastomer O-ring seal. Connection between the cable conductors and stator leads shall be made with threaded compression type binding posts permanently affixed to a terminal board. Wire nuts or crimping type connection devices are not acceptable. The motor and pump shall be designed and assembled by the same manufacturer. The combined service factor (combined effect of voltage, frequency and specific gravity) shall be a minimum of 1.15 the motor shall have a voltage tolerance of plus or minus 10% the motor shall be designed for operation up to 40oC ambient temp. and with a temp. rise not to exceed 85oC. This chart shall also include data on starting and no-load characteristics. The motor and the cable are capable of continuous submergence underwater without loss of watertight integrity acc. To protection class IP68 (20m), the rated power shall be adequate so that the pump is not overloaded throughout the entire indicated pump performance curve.

Power cable includes two conductors 1.5 mm for the monitoring of thermal switches and optional protecting sensors.

2.2.4 Bearing

The pump shall be provided with grease lubricated thrust and radial bearings designed for all loads imposed by the specified service. Bearing life for all pump and motor bearings shall be 100,000 hours minimum

2.2.5 Mechanical Seal

Each pump shall be provided with a tandem mechanical shaft seal system consisting of two independent seal assemblies. The seals shall operate in an oil-reservoir that hydro-dynamically lubricates the lapped seal faces at a constant rate. The lower, primary seal unit, located between the pump housing and the oil-chamber, shall contain one stationary and one positively driven rotating tungsten carbide ring. The upper, secondary seal unit, located between the oil-chamber and the motor housing, shall contain one stationary tungsten-carbide seal ring and one positively driven rotating tungsten-carbide seal ring. Each seal interface shall be held in contact by its own spring system. The seals shall require neither maintenance nor adjustment nor depend on direction of rotating for sealing. For special applications other seal face material shall be available. Other seal types shall not be considered acceptable or equal to the dual independent seal specified. Each pump shall be provided with an oil chamber for the shaft sealing system, the drain and inspection plug, for the oil, shall be accessible from the outside.

2.2.6 Rotor and Stator

The pump shall be two-stage design employing a convoluted rotor operating in a similarly convoluted stator. The convolutions shall be configured to form a cavity between the rotor and stator which shall progress from the pump's inlet to discharge port with the operation of the rotor. The fit between the rotor and stator at the point of contact shall compress the stator material sufficiently to form a good seal and to prevent leakage from the discharge back to the inlet end of the pumping chamber.

2.3 Spare Parts and Special Tools

The Contractor shall specify and supply the special tools required for equipment maintenance and for 2 years of operation.

3 EXECUTION

3.1 Inspection Before Erection

A) The Contractor shall check the setting and alignment of pre-embedded parts as well as the dimensions and setting of recesses in the civil works for embedded parts.
B) The shaft mixers (blade paddles, shaft, driving device) shall be assembled on site and checked before installation.

3.2 Field Quality Control

3.2.1 Inspections Before and After Concreting

a) The following inspections shall be carried out:

a) Holes position
b) Flatness, verticality, horizontality of the embedded parts,

b) Erection tolerances:

Refer to Section 01020

3.2.2 Dry Tests

1. Examination of paintwork.

3.2.2.1 General

a) The Tests on Completion shall consist of the following:

1. Installation inspection;
2. Pre-commissioning tests
3. Commissioning tests;
4. Overall setting-to-work.

The Contractor shall submit to the Engineer for approval a comprehensive program and detailed proposals of the Tests on Completion.

b) The Tests and the Overall Setting-to-Work shall be carried out under the control and supervision of the Contractor. The Contractor shall provide an accredited representative and all other labour, materials, all instruments including indicators, gauges, and other measuring instruments and all other apparatus required for the Tests on Completion, together with oils and stores. All instruments shall be calibrated prior to the Tests.

3.2.2.2 Installation Inspection

a) When the Contractor is satisfied that the unit sets have been properly installed, he shall inform the Engineer who will carry out the installation inspection.
b) The unit will be inspected with regards to compliance with this Specification and approved drawings. In the event of any items of plant failing to meet the requirements of this Specification or the approved drawings, or the workmanship being defective, the Contractor shall take immediate steps to remedy the deficiency to the satisfaction of the Engineer.

3.2.2.3 Pre-Commissioning Tests

a) Pre-commissioning tests shall be carried out after any deficiencies noted during the installation inspection have been remedied to the satisfaction of the Engineer.
b) All associated instrumentation (e.g. vibration and temperature monitoring equipment) shall be checked to ensure correct functioning.
c) Hydrostatic pressure test shall be carried out on each pump body and discharge pipework to check for leaks. The test pressure shall be the pump shut-off head.

3.2.2.4 Commissioning Tests

a) For each agitator, checking of operation conditions for nominal flow and during 24 hours. The supplier shall provide mixing effectiveness testing report, taking samples from upper, middle, lower, left, middle and right part of sections of incoming and outgoing water ditches, in order to check the effectiveness of mixing. Each tank shall fit individually with requirements.
b) For each pump set and shall include but not necessarily be limited to the following:

   ~ performance tests to establish that the pump sets operate satisfactorily over the entire operating flow range and to demonstrate the dynamic stability of the pump set operation under all Site conditions;

   ~ vibration monitoring to demonstrate compliance with specified vibration severity limits;

   ~ reverse rotation of the pump set due to backflow;

   ~ simulation of power failure and emergency shutdown conditions when the pump sets operate at full pump speed.

   ~ Performance proving tests shall be carried out on one pump set at a time by pumping clean water. Flow rates shall be measured using flow measuring instruments to be provided by the Contractor for testing of all the pumps. The flow meters may be installed at a suitable location. The contractor shall remove the flow meters from their locations after completion of all tests.

   ~ Pressure measurements shall be taken at a number of locations as directed by the Engineer, including the outlet flange of the discharge bend of pump. Sufficient measurements shall be taken to enable the performance of the pumping system to be evaluated, including losses in the discharge pipe work.

c) If the test results cannot satisfy technical requirements, the supplier has to make rectification, changing equipment or taking improvements until the requirements in tender documents are reached. All relative rectification expenses will be undertaken by the supplier.