

REPUBLIC OF LEBANON
Ministry of Public Health
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

**Supply and Installation of Medical Equipment, Furniture
and related Civil and Electromechanical Works
for CT Scanner, Standby Generator and ICU Unit
to Al Jabal Hospital – Kornayel**

VOLUME 2.2 – SPECIFICATIONS

ELECTROMECHANICAL WORKS

- ICU AT FIRST FLOOR PLAN
- CT-SCAN AT GROUND FLOOR
- GENERATORS ROOM

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MECHANICAL WORKS

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Division 15

MECHANICAL WORKS

GENERAL CONDITIONS (15010)

A. Scope of Work

Works under this Contract shall include, but not be limited to, the supply, installation, testing and delivery in good operating conditions of all systems, equipment, components, etc... as specified under their respective clauses, relevant drawings and the following general stipulations.

1. Extent of Supply

- a. All necessary components, accessories, manpower, tools, scaffoldings, cutting and patching in walls and slabs, painting, testing, etc..., shall be provided by the Contractor at his own expenses to execute the specified systems complete and in good working conditions.
- b. Accessories and particulars specified with each item are deemed shall be minimum requirements and do not limit the Contractor's supply to them.
- c. All accessories and particulars not specifically listed, but necessary to the satisfactory operation and protection of the installation shall be included in the Contractor's supply at no additional cost.
- d. Easily removable and sturdy construction protective guards on all moving equipment or live components.

2. Drawings

- a. Drawings show the general arrangement of equipment and routings of ducts, pipes, cables or conduits. Minor modifications may be allowed to suit Contractor's equipment and site conditions, subject to the approval of the Engineer.

3. Availability of Materials

- a. At the bid stage, the Contractor shall make sure that he can supply all items specified within the time limit set for the project. Any reservations shall be submitted to the Employer before Tender closing date.
- b. Equipment and material not available on the local market, or temporarily out of stock, shall be ordered at an early date after obtaining the Engineer's approval to avoid delays or stoppage of work.
- c. Contractor shall be the sole responsible for resulting delays and the Engineer reserves himself the right to order equipment and material and air freight them, if need be, at Contractor's expenses and responsibility.

4. Submittals

- a. Prior to ordering and/or installation, the Contractor shall submit to the Engineer's approval samples, technical catalogues, performance curves, shop drawings, construction details, etc..., for equipment, materials and installations specified under this Contract.

- b. The Contractor shall also submit to the Engineer the necessary dimensioned drawings showing all sleeves and openings required by him ahead of time before concrete pouring or execution of masonry structures.
- c. Before taking over the installation, the Contractor shall submit to the Engineer operating and maintenance instructions manuals for the whole works and shall instruct the Engineer or his representative on the method of operation and maintenance of the installed systems.

5. Coordination

- a. The Contractor shall take into consideration that the works specified shall be carried out in conjunction with other trades. He shall therefore be responsible to coordinate the execution of his works with these other trades and at no additional cost to the Employer.
- b. Prior to ordering or installation of electrical systems, equipment, controls and/or components, the Contractor shall ascertain himself with the local power authority of the electric supply characteristics.
- c. The Contractor shall foresee all openings required in walls, slabs or structural members to reduce to a minimum piercing and breaking works.
All works of cutting, patching, piercing, making good, etc..., as well as all excavation and backfilling, cleaning the site of excess material, debris and dirt resulting therefrom, shall be executed by the Contractor and at his own expense.
- d. Whenever cutting and drilling is made on finished surfaces, the Contractor shall make good these surfaces by returning them to their finished original condition and at no additional costs.

B. Equipment and Items Supplied by the Contractor

All equipment and materials supplied by the Contractor shall be brand new, of the latest model and bearing manufacturer's name and corresponding particulars as deemed necessary.

Unless specifically mentioned otherwise, all equipment and items specified and/or shown on the drawings shall be transported, installed, connected to Mechanical and Electrical Services, finished and tested in good working and operating conditions by the Contractor.

C. Tender Drawings

The Contractor shall be responsible for the execution of the works in accordance with the Tender Drawings. Modifications to these drawings may be allowed to suit equipment supplied by the Contractor and conform site contingencies, subject to the approval of the Engineer.

All drawings accompanying the Specifications are shall be read in conjunction with each others and shall be considered as a whole. Any works indicated on them and not specifically mentioned in the Specifications, and vice-versa, are deemed shall be included in the overall Scope of Work.

Tender Drawings are design and not working drawings; they include general layouts of various systems and equipment shall be provided and installed.

While every effort has been made to produce comprehensive Tender Drawings, and unless specifically indicated otherwise, these drawings show approximate locations of machines, equipment, pipings, valves, ductworks, cables, feeders, etc... Exact locations shall be determined by the Contractor to comply with selected equipment requirements and spaces reservations in full coordination with other trades and subject to the Engineer's approval.

D. Shop Drawings

Before starting works on site or ordering materials and equipment, the Contractor shall submit to the Engineer's approval shop drawings showing the followings:

- a. Exact layout of piping and ductworks, double line, with exact distances, and levels in relation to fixed references, and exact location of supports, at a scale not less than 1/50. Toilet areas shall be drawn at a scale 1/20.
- b. Exact dimensions, location and clearances of equipment and machines.
- c. All accessories with exact location.
- d. Exact layout of electric cables, feeders, with exact distance and levels in relation to fixed references.
- e. Clearances and accesses required for operation and maintenance.
- f. Section details in typical location where necessary.
- g. Plans and sections of all the shafts, at each level, showing installation, fixation and supporting details at a scale of 1/10.
- h. All installation, fixation and supporting details as recommended by the manufacturer.
- j. Particular details pertaining to special conditions that may be required by the Engineer.
- k. Composite shop drawings, showing simultaneously all trades to indicate their coordination.

Suppliers' approved shop drawings shall be submitted to the Engineer after ordering. Should it be necessary, working drawings shall be revised accordingly.

The Engineer reserves himself the right to approve, modify, alter or reject shop drawings if found incomplete or not complying with the requirements of the Tender Documents.

E. Codes and Standards

Where equipment, materials, methods of erection and testing are specified to conform with certain International Codes and Standards, they shall conform with their latest edition. A copy of the relevant standard shall be submitted with each submittal for approval.

Electric equipment and material supplied under Mechanical Systems shall conform with the recommendations of the International Electro-Technical Commission.

Unless specifically stated otherwise, all Electrical Installation Works shall be tested in compliance with the Regulations for Electrical Equipment of Buildings.

In addition to the above, Works shall conform with the regulations and ordinances of Local Authorities.

Abbreviations are to mean the following:

ANSI - American National Standards Institute

ASTM - American Society for Testing and Materials

ASME - American society of Mechanical Engineers

AGA - American Gas Association

NF - Norme Francaise

BS - British Standards

DIN - Deutsches Institut fur Normalisierung

ISO - International Standardization Organization

FM - Factory Mutual

NFPA - National Fire Protection Association

NBS - National Bureau of Standards

SAE - Society of Automotive Engineers

UL - Underwriters' Laboratories Inc.

F. Equipment Capacities and Particulars

Capacities given in the Specifications, Schedules or shown on the drawings are the minimum acceptable capacities; the Contractor shall select, install or construct all equipment and systems to meet at least these values.

All equipment shall be suitable for operation under the severest conditions shall be expected for the Project.

No extra payments shall be given to the Contractor as a result of selection, installation or construction of equipment and systems having capacities or sizes in excess to the specified requirements.

All equipment, panels, cables, control gears, circuit breakers, systems, etc,... shall be derated to the ambient design conditions stated for the project.

G. Omissions from Tender Documents

The Contractor is required to inform the Employer of possible omissions or apparent discrepancies that may be encountered in the Tender Documents (Book of Specifications and Drawings), which, if approved by the Employer, will form the object of an addendum to the Specifications.

Failure of the Contractor to point out possible omissions or discrepancies shall be considered that he has included the effects of these discrepancies in his pricing, and shall not be entitled to any compensations as a result therefrom.

H. Interference and Erroneous Locations

The Contractor shall verify on site all data and final locations of work executed under other trades to coordinate systems interconnections accordingly.

In case of interference or erroneous locations with respect to structures, equipment, etc,... the Contractor shall supply all labor and materials necessary to complete the work in an acceptable manner.

J. Coordination of Trades

The Contractor shall foresee in time all openings required in walls, beams, or slabs to reduce a minimum all works of cutting, piercing and making good. He shall be responsible for dimensioning of sleeves, forms, inserts, access doors, etc... Furthermore, if new concrete pouring is shall be carried out he shall install all drains, pipes, conduits, boxes and sleeves wherever required and/or shown on the drawings before concrete pouring.

The Contractor shall be in constant contact with the Concretor to inform him of above requirements ahead of time and shall submit to him all relevant drawings and details showing locations and sizes of sleeves and openings.

All cutting and patching works in slabs and walls, all preparatory or complementary works required, as well as all labor and material supply in connection with these works, shall be at the Contractor's expenses who shall not be entitled to any payments or claims as a result thereof no matter how difficult or precise they may come out shall be.

The Contractor is advised that the works specified herein shall be carried out in conjunction with other trades and he shall be responsible to coordinate the execution of his works with them and at no additional cost to the Employer.

K. Hook-Ups

Hook-ups to other systems and equipment shall be provided to ensure the satisfactory performance of the overall project.

L. Protection of Electrical Equipment

Electrical equipment shall not be stored outdoors and shall be constantly protected from weather, dripping or splashing water. When installed or stored in moist areas, acceptable means to prevent moisture damage shall be provided.

Should any equipment or material be subjected to possible damage by water, it shall be dried out thoroughly and put through a special dielectric test as directed, at the expenses of the Contractor; if permanently damaged, it shall be replaced at the Contractor's own expenses.

M. Programme of Work

Within four weeks after award of Contract, the Contractor shall submit to the Engineer's approval a detailed programme of work for all phases of the project, showing the proposed dates and periods for material submission for approval, getting approvals, ordering, shipping, preparation of working drawings, equipment arrival on site, start of erection, progress of erection, completion, testing and final taking-over. Within the same period, the Contractor shall submit lists of equipment and materials, with names of proposed manufacturer's, and drawings of inter-related items. Lists and Drawings are to show submission dates.

The Contractor shall allow in his programme for the time needed by the Engineer for approval of materials and shop drawings which should be between two to three weeks.

No work on site shall be allowed to proceed unless the programme of work is submitted and approved by the Engineer.

N. Submittals

All submittals shall be presented to the Engineer with a covering letter in which the Contractor states the subject and purpose of the submittal.

Each submittal shall conform with the following stipulations:

1. Working Drawings or Shop Drawings & Materials Submittals

- a. Two months prior to commencement, Contractor shall submit for approval detailed shop drawings (working drawings) showing to-scale dimensions of equipment, pipes, ducts etc.. in plan and elevation with clearances and relation of same to space assigned, showing also location, type and spacing of supports to equipment, pipes, ducts, etc.. Scale shall be not less than 1/50 for general plans and 1/20 for toilet areas.
- b. Shop drawings for equipment and materials shall include detailed manufacturer's drawings, detailed catalogues and descriptive literature showing type, performance characteristics, construction, component parts, dimensions, arrangement, operating clearances, capacity, electrical characteristics, power requirements, motor, drive and testing information and all other details as mentioned in paragraph D (general conditions).
- c. Indicate, with reasons any deviations from the Specifications and Drawings. No modification to the Contract Documents is authorized unless issued in writing in a change order by the Engineer.
- d. No equipment or materials shall be purchased or delivered to Site until such equipment, materials have been approved by the Engineer.
- e. Shop Drawings shall be submitted in triplicate with each submittal.
- f. Shop Drawings for equipment and material shall be submitted in triplicate with each submittal. At least one copy of catalogues shall be original and not photocopied.
- g. Refer to other sections for other requirements of Working or Shop Drawings.

2. As-Built Drawings

Contractor shall provide As-Built Drawings and submit them for the Engineer's approval. After approval of as-built drawings, the Contractor shall submit the original plus a reproducible mother print of each drawing. Moreover, two sets of blue prints of each drawing shall be submitted with the originals.

3. Samples

Two samples of each item shall be required with each submittal and three sets of technical literature's or catalogues, with at least one original copy.

P. Consistency of Supplied Items

It is pointed out to the Contractor, that equipment controls, accessories, etc..., falling under the same service, shall be supplied from the same manufacturer unless specifically directed otherwise by the Engineer.

The followings illustrate equipment and accessories considered shall be falling under the same services:

- a. Pumps.
- b. Pipes and accessories.
- c. Valves.
- d. Controls.

- e. Insulation.
- f. Cables and wires.
- g. Panel boards.
- h. Electric gears (breakers, switches, starters, etc...)

Q. Approved Manufacturers

In specifying and selecting equipment, fixtures or accessories, model numbers of certain manufacturers' catalogues are referred to; this procedure is adopted to describe the type, shape, and/or function of the items specified, and to establish standard of quality and performance.

Other items from approved manufacturers, judged by the Engineer shall be similar in shape and performance to the one specified, will be accepted. Reference to approved manufacturers and model numbers does not imply approval of same. Contractors shall submit all equipment and materials for approval irrespective of whether a model number or approved manufacturer is listed or not.

It is pointed out that the term "or approved equal" shall mean items or equipment approved by the Engineer, whose decision in approving or rejecting shall be final and not subject to any justifications.

R. Samples

Before ordering and starting the works, the Contractor shall submit to the Engineer's approval samples of the various items shall be supplied and installed by him. These shall include namely:

- a. Pipes, pipes fittings and pipes supports.
- b. Valves and specialties items (i.e. safety valves, strainers, air vents, etc...)
- c. Insulation for pipes and equipment.
- d. Drains, clean-outs, gates, manholes, covers, etc...
- e. Meters, gauges and controls.
- f. China ware and chrome fittings.
- g. Bathroom accessories.
- h. Cables and wires.
- j. Conduits, trunkings, trays, boxes, accessories, etc...
- k. Sockets, plugs, switches, etc...
- l. Circuit breakers, starter, timers, etc...

The above illustrate the main types of samples required, and does not limit the supply of these items only. The Engineer reserves to himself the right to request any sample not specifically mentioned above at any stage of work progress.

All samples are deemed shall be submitted at the Contractor's own expenses and at no additional charges to the Employer.

S. Maintenance Prior to Completion Date

The Contractor shall be responsible for the maintenance of all equipment and systems installed by him until final acceptance by the Engineer. He shall therefore take necessary measures to insure adequate protection of all equipment and materials during delivery, storage, installation and shutdown. This responsibility shall include all provisions required to meet the imperatives incidental to the delays pending final test of systems and equipment under seasonal conditions.

After installation of systems have been completed, the Contractor shall operate them for a period of time sufficient to complete all tests, balance, adjust and demonstrate that performance are in accordance with design.

T. As-Built Drawings

Upon completion of the Works, the Contractor shall submit to the Engineer the original plus a reproducible mother print and two sets of blue prints of the approved as-built drawings showing the final routing, layout and location of equipment, pipes, cables, etc...

These drawings shall be submitted within one month after completion date, and no payment will be effected upon completion unless the drawings have been received by the Engineer.

U. Operation and Maintenance Instruction Manuals

The Contractor shall provide for each system, equipment and accessories, three copies in bound booklet form containing the following information:

1. Brief description of each system and piece of equipment with basic operating features
2. Descriptive literature of equipment and components with manufacturer's name, model number, capacity rating and operating characteristics
3. Service manual prepared by manufacturer for every major piece of equipment giving operating and maintenance instructions, starting and shut-down instructions, lubrication instructions and list of possible breakdown and repairs
4. Manufacturer's list of general spare parts for every piece of equipment, with unit prices.
5. Manufacturer's list of recommended spare parts for one year of operation for every piece of equipment, with unit prices
6. Detailed and simplified one line, color coded flow diagram of each system with tag number, location and function of each valve and instrument
7. Detailed and simplified color coded as-installed wiring diagrams of motor controllers and automatic controls with tag number, location of each instrument and electrical device with description of sequence of operation and interlocks.

Instruction manuals shall be submitted in draft form for review and approval prior to final issue and at least four weeks in advance of completion date of the system. Completion certificate shall not be issued if the above are not submitted and approved.

V. Access Doors and Frames

The Contractor shall install work shall be readily accessible for operation, maintenance and repair. Approved deviations from the Drawings may be made to accomplish this.

The Contractor shall ensure that access doors and frames are provided for easy access to concealed equipment, controls, valves, traps, vents, drains, clean-outs, and other devices requiring periodic operation, inspection and maintenance.

Access doors and frames are shall be provided by others. Provide details, dimensions and locations of access doors required and submit for approval in sufficient time to enable doors shall be installed during normal course of work.

Access doors are shall be identified to indicate location of concealed work. Method and schedule for identification of access doors is shall be approved.

W. Nameplates, Labels, Tags and Charts

Each piece of equipment shall have a conspicuous certified nameplate permanently attached at factory, printed or stamped clearly with name and address of manufacturer, equipment model number, serial number, date of manufacture, electrical characteristics, performance rating or duty, pressure, temperature or other limitations and other pertinent data.

Equipment, instruments, controls, electrical devices, valves etc. shall be labeled and identified as to duty, service or function. Label controls and electrical devices to indicate clearly what they control.

Labels shall be of laminated Bakelite with black surface and white core with incised lettering nomenclature written in English.

Labels shall be attached to equipment etc. or to adjacent permanent surfaces in an approved permanent manner.

Controls and instruments that cannot be easily identified shall be tagged with Bakelite labels.

All valves and controls except equipment shut-off valves located at equipment, shall be tagged.

Tags shall consist of 5cm diameter by 1.5mm thick aluminum sheet with stamped numbers and letters filled with black paint.

The Contractor shall submit for approval a schedule of equipment and devices shall be labeled and tagged, with suggested nomenclature

Charts are shall be prepared of schematic flow diagrams of each piping system with location and function of each valve and with type and size of each essential feature of the system, and submitted for approval.

Schedules for equipment lubrication and maintenance and essential operating instructions, shall be prepared in chart form and submitted for approval.

Charts shall be mounted on wooden plaques or 6 mm Masonite boards, cover with heat bonded clear plastic laminate or frame under glass and permanently fix with four brass screws at approved locations.

XA. Instruction to Personnel

The Contractor shall be responsible to instruct the personnel team that may be assigned to him by the Employer during execution at no extra charges. Personnel instruction shall include allowing the personnel team to attend installation works, be instructed on the use, operation and maintenance of the various systems, components and equipment.

XB. Spare Parts

Spare parts necessary for the normal running of equipment or items during the Guarantee period shall be supplied by the Contractor as part of his responsibilities under this Contract except oils and greases.

XC. Tools

The Contractor shall supply all standard and special tools needed for routine maintenance, adjustment, operation or normal overhaul of equipment supplied by him.

Tools shall be brand new, high grade quality and shall include general purpose spanners, wrenches, screw drivers, greasing guns, etc,... as well as all specialized and customized tools.

XD. Site Facilities

The Contractor shall be responsible to provide for himself all site offices and covered storage facilities he needs in coordination with the Engineer.

Stored equipment and items shall be kept clear off the floor and protected from dust and other deteriorating agents.

XE. Works Not Included

The contents of this clause shall not relieve the Contractor's responsibility to coordinate his work with other trades to ensure that execution of works not included in his Contract are carried out on time and to his satisfaction. He shall remain responsible for proper functioning of systems connected with other trades for their installation.

- a. Concrete, sump pits and concrete pipe trenches.
- b. Water supply and sewer and rain water outside property limits.
However, the Contractor shall coordinate connections to municipal mains with the authorities to obtain permits and authorizations for these connections.
He shall pay for expenses related thereto as well as to works shall be executed whether carried out by himself or by a Contractor appointed by the authorities.
- c. Close to each equipment control panel, each electrically operated equipment (pumps, etc,...), and motor control centers supplied under Mechanical Works, an adequate power supply outlet will be provided by the Electrical Contractor.
Final extensions and connections between these outlets and the corresponding panel and/or equipment, as well as all associated controls, wirings, etc,... are included in the Mechanical Works.

XF. Coordination With Civil Works

Before pouring, the Contractor shall prepare a template to the exact dimensions of equipment anchor bolts which shall be rigidly secured on the template to the desired depths.

When only openings for anchor bolts are required, the templates shall be made with wood strips rigidly secured on it at the bolts locations.

XG. Design Conditions

Unless stated otherwise the design conditions shall be as follows:

	Summer		Winter
	DB (°C)	RH (%)	DB (°C)
a. Internal Conditions	20 - 24	50 - 60	24
	24	50 - 60	24
	20 - 24	50 - 60	
	24	50 - 60	24 - 27
	24	50 - 60	24
			21
b. External Conditions	33		1
	25		--

c. Electric Power 3 phase, 4 wire, 50 Hz, 380 volts between phases

220 volts between phases and neutral
with solidly earthed neutral

All equipment, cables, control gears and systems shall be derated to conform with the above mentioned conditions.

XH. Noise and Vibration

All equipment shall operate under all conditions of load without sound or vibration which in the opinion of the Engineer is objectionable and above the criteria limits set here below.

The noise level resulting from equipment ducts, air outlets, etc.. and heard in the conditioned spaces shall not result in a noise level in such spaces exceeding the sound levels below listed :

Private rooms	NC 25-30
Wards	NC 30-35
Laboratories	NC 35-40
Corridors	NC 30-35
Public areas	NC 35-40
Pumps room	NC 60
Generator room:	NC 95 (inside the room) NC 60 (outside the room)

Contractor shall be responsible for achieving the above noise limits and he shall provide all necessary noise attenuation features and accessories such as sound absorbers for equipment, pipes, etc.. whether or not they are indicated on Drawings or specified.

Vibration control shall be provided. Equipment shall not result in any vibration transmitted to the building. Provide vibration isolators, inertia blocks etc.. to achieve the above.

XJ. **Guarantee**

The Contractor shall guarantee all his works for a period of one year beginning after the issuing of the Completion Certificate of all the works specified herein. The guarantee shall cover all works, manpower, spare parts, replacements, etc..., resulting from failure of equipment, systems and accessories supplied by the Contractor. Guarantee shall apply also for perfect mechanical operation of the system and equipment, acceptable noise and vibration levels and reasonable consumption of power, fuel and water.

If during the guarantee period any equipment or material proves defective or any part of system fails to function properly, equipment is shall be replaced and defects and malfunctions corrected as directed by the Engineer.

If during the guarantee period any piece of equipment is replaced or rebuilt, the guarantee period for this equipment is shall be extended for a new period equal to the original guarantee period.

Contractor shall provide necessary skills and labor to assure proper operation and to provide regular and preventive maintenance required for equipment and controls during the guarantee period, on a continuous 24 hour basis.

Act promptly to correct problems arising in operation of equipment or system.

Provide the Employer with monthly inspection certificates of equipment, record findings on a check list and certify that each piece of equipment has been examined, is operating as intended and has been properly maintained as recommended by the manufacturer.

Check all controls monthly to ascertain that they function as designed.

Spare parts for normal wear and tear are shall be provided by the Employer.

PAINTING (15020)**A. Scope**

Supply and apply all painting to the various services provided under this Contract.

Painting shall be executed in accordance with the requirements and instructions of this Section.

B. General Requirements

Surfaces requiring prime painting shall be cleaned thoroughly of rust, scale, oil, grease and dirt. Use wire brushing, sand blasting or solution cleaning as needed.

All items that have rusted or corroded shall be cleaned and/or painted to the satisfaction of the Engineer. No painting shall be applied on rusted, damp or dirty surfaces.

The paint shall be evenly and well brushed out to prevent drops, runs or saggings. Care shall be taken not to paint over controls, labels and nameplates.

C. Paint Types

The primer and finishing coats for painting hot surfaces shall be special heat resistant type acrylic base paint.

The primer and finishing coats for painting cold surfaces shall be acrylic base paint.

The above shall not relieve the Contractor to supply specific paint types other than those mentioned herein and which may be necessary shall be used for specific applications.

D. Piping, Frames, Supports and Ductworks

All black steel piping including flanges, bolts, nuts, cast iron valves and accessories, valve wheels and all ferrous parts are shall be painted with two coats of zinc chromate primer whether or not they are shall be insulated. When bare or exposed to view, they are shall be further painted with two coats of approved oil paint.

Ductwork shall be painted inside or outside with one coat dull black fire resistant paint where visible through air outlets or through the false ceilings.

Hangers and supports including clamps, rods, bolts, nuts etc.. shall be painted with two coats of zinc chromate primer and where exposed to view with two additional coats of approved oil paint.

All exposed uninsulated surfaces shall receive two coats of primer and two coats of finishing paint. Special etch primers shall be used for galvanized surfaces (pipes, ducts etc....)

Unless mentioned otherwise, uninsulated and unwrapped pipes, flanges, valves, laid in trenches, wall chases, in fill or underground, shall receive two layers of asphalt solution soaked jute applied as follows:

- a. Clean pipe surface as stated here above and apply one coat of asphalt over the bare pipe.
- b. Wrap pipe with the first asphalt soaked jute layer and apply one coat of asphalt over the first jute layer.

- c. Repeat the above two operations for the second layer.
- d. Under tiles, protection may be replaced by embedding pipes in an asphalt cork sawdust cement mixture.

E. Equipment and Panels

Equipment and panels installed under this Contract shall have two shop priming coats of corrosion protective paint and at least two factory applied finishing coats.

All factory painted surfaces shall be cleaned thoroughly and inspected on site for scratches and etchings and shall be retouched where necessary.

F. Color Coding and Identification

The finishing coat colors for exposed metallic surfaces or insulated surfaces shall conform with the schedule:

- a. All factory painted equipmentKeep their color
- b. Equipment not factory painted Gray
- c. Structural frames and supportsBlack
- d. Pipe services as per ASME color code.
- e. DuctsAluminum

Piping, cables and wires shall be identified at intervals not exceeding four meters and at all crossings through slabs and walls. Identification shall include:

- Type of service.
- Direction of flow where applicable
- Size

Colored cables and wires shall be used and the same color shall be maintained throughout the project for the same circuit or function. A schedule of colors shall be submitted by the Contractor for the Engineer's approval and adoption.

The type and flow direction of the fluid conveyed in pipes and ducts shall be painted in red at intervals not exceeding four meters and at all crossings through slabs and walls.

ELECTRICAL WORKS FOR MECHANICAL SYSTEMS (15030)**A. Scope**

Supply and install all Electrical Works, equipment and accessories specified under the various Mechanical Systems.

Electrical Works shall comply with any of the following standards:

ANSI, NEMA, BS, VDE, DIN, IEC, UTE.

All electrical equipment, materials, accessories, etc,... shall be supplied for the Mechanical Systems, as well as all electrical works and tests shall be done shall conform also with the requirements of the relevant Specifications for the Electrical Systems.

The scope of the Electrical Works under this section includes the supply and installation of the followings:

- a. Motor control centers, motor control panels for each item or system and housing all protection gear, switches and controls required for the specified function.
- b. All cables and wires between equipment and the corresponding motor control center or motor control panel.
- c. All electrical equipment, wiring, cables, conduits, boxes, earth connections, control switches, starters, circuit breakers, isolating switches, relays, contactors, protective gear or equipment, transformers, etc,... and all other necessary item or components required for the satisfactory operation, control and protection of the systems.

B. Works Not Included

The following electrical items are not included and will be supplied by the Electrical Contractor.

- a. Power close to each electrically operated equipment not fed from a control panel.
- b. Main feeder to the motor control centers and control panels of mechanical equipment.

C. General Requirements

- a. Ratings of circuit breakers serving electric motors are design values and must be checked and readjusted, if need be, to conform with motor actual power and rating as recommended by motors Manufacturers.
- b. Power supply connections to vibrating or rotating machinery shall be made through adequate metallic flexible conduits or tubings through which cables and wires shall be drawn.
- c. Cables shall be color coded for identification. Red, Yellow and Blue shall be used for phase conductors, Black for neutral and Green for earth conductors.
- d. Control voltage for starters and control circuits shall not exceed 220 volts.
- e. Shop and Installation Drawings are shall be submitted for approval prior to ordering materials and equipment. Drawings to include the following:

- i. Complete technical data on all motor starters, motor protection relays, sensing units, control accessories, etc.
- ii. Instructional details of equipment, particularly motor control centers and panels
- iii. Wiring diagrams of all power and control circuits
- iv. Installation details of motor control centres and panels and of control and sensing accessories
- v. Exact routing of power and control cables, wiring and conduits
- vi. Feeder termination details at motor control centres, starters, motors, isolating switches, control and sensing accessories etc.
- f. Power and control wiring to run in conduit unless otherwise specified.
- g. Power and control wiring to run in separate conduits.
- h. Rigid conduits are not to terminate in nor be fastened to a motor frame or base.
- j. Flexible conduits shall be used at motor connections. Allow sufficient slack to permit motor to slide over adjustable length of motor base. Length and radius shall be sufficient to permit bending of feeder cables without damage to conductor or its insulation. Flexible conduits are not shall be used in place of rigid conduit except at motor connections, unless otherwise specified.
- k. Conduits are shall be supported with conduit supports in an adequate approved manner.
- l. Conduits are not to cross pipe or vent shafts, ducts or openings. They are shall be run a minimum 100 mm away from pipes of non-electrical services.
- m. Detailed control wiring diagrams and a list of control equipment with descriptive literature are shall be submitted for approval. Free hand field wiring diagrams or sketches will not be accepted.
- n. Circuits shall be arranged to satisfy operating requirements specified for various equipment driven by electricity and other requirements pertaining to proper functioning and operation of equipment.
- p. Circuits shall be protected with high rupturing capacity fuses or circuit breakers. Auxiliary supply for controls, other than from main power circuit, shall be effectively isolated by auxiliary contacts on main isolator.
- q. Motors shall be earthed by connecting green insulated conductor from earthing bushing in starter to motor frame. Run earth conductor together with circuit wiring and terminate in motor terminal box, provided earth terminal in box is connected to motor frame. If this is not feasible, extend earth conductor through insulated bushed opening in terminal box and connect to motor base.
- r. Equipment shall be earthed by connecting non-current carrying metal parts of system to earth source. Non-current carrying metal parts include conduits, cable trays, outlet boxes, cabinets, enclosures, doors, grilles, and barriers protecting or shielding electrical equipment from direct access.
- s. Detailed wiring diagram is shall be fixed inside each starter enclosure cover to clearly indicate circuits.

- t. Control and power wires are shall be identified either by distinctive colored insulation, engraved tags or other approved method.
- u. Circuit breakers earth fault detection and interruption are shall be coordinated with those of main incoming breaker on main distribution panel.
- v. Approved Manufacturers: Equipment and accessories shall be obtained from one of the following:
 - Westinghouse (U.S.A)
 - Square D (U.S.A)
 - General Electric (U.S.A)
 - Siemens (Germany)
 - Klockner - Moeller (U.K.)
 - AEI (U.K.)
 - GEC (U.K.)
 - English Electric (U.K.)
 - Merlin Gerin (France)or approved equal.

D. Conduits

Size is shall be minimum 20 mm unless otherwise specified.

Steel conduits are shall be welded, drawn, heavy gauge, to BS 4568 Part 1 or approved equal, galvanized internally and externally and threaded both ends.

Fittings for steel conduits are shall be threaded, galvanized or cadmium plated malleable iron specifically designed for size and type of conduit.

E. Wires and Cables

Power wires and cables are shall be 600/1000 V grade, to BS 6004. Single conductor wires and multicore cables shall have high conductivity tinned copper wire conductors insulated with PVC compound, with additional PVC sheath for multicore cables.

Control wires and cables are shall have copper conductors tinned annealed, minimum area 1.5 sq mm. Insulation shall be moisture resistant flame retardant PVC compound. Wires and cables shall be rated for 220 V service. Multicore cables for control and signaling shall be PVC insulated copper conductors, PVC sheathed, to BS 6346.

Control wires and cables are shall be provided with special heat resistant insulation or corrosion resistant sheath where required.

Armoured cables shall have the armour as single layer of galvanized steel wire under the PVC sheath.

Connections to motors shall be single conductor wires pulled inside conduits, or multicore cables armoured or non armoured and fixed on cable trays or supports.

Special conditions: where required high temperature resistant cables, silicone rubber, cross linked polyethylene, MICC, or approved equal, corrosion resistant sheath is shall be provided.

F. Electric Motors

Motors shall be supplied by driven equipment manufacturer, shall be as specified for equipment concerned and specifically supplied for available supply voltage and frequency.

Motors 1/2 horsepower and under shall be single phase and over 1/2 horsepower shall be three phase. Motors shall be totally enclosed, fan cooled type, unless otherwise specified.

Motors shall have Class B insulation with 80 deg. C continuous temperature rise above average ambient temperature of 40 deg. C, unless otherwise specified.

Motors that will operate outdoors are shall have Class F insulation.

Motors operating in ambient temperatures exceeding 40 deg. C shall be tropicalized and derated for satisfactory operation.

Motors shall be rated for continuous operation.

Power shall be adequate to operate driven equipment without motor overload under all operating conditions and loads and throughout capacity range of equipment. Motor shall be capable of delivering full rated output when operating at voltage deviating by 5% from rated voltage at rated frequency.

Starting and torque characteristics shall be as required by driven equipment.

Speed shall be as specified for equipment concerned.

Conduit terminal box on motor shall be approved model for type of motor enclosure. Motor windings shall be connected to terminals in terminal box at factory. One additional earthing terminal shall be connected to motor frame.

Motor base shall be adjustable where motors are directly connected to driven equipment, unless otherwise specified. Motors connected to equipment through V-belt drive shall have adjustable sliding base. Fractional horsepower motors shall have slotted mounting holes in base.

G. Starters

Starters for three phase motors shall be magnetic type to automatically disconnect motor from power supply in case of supply failure, excessive voltage drop, overcurrent and lack of balance in phases. Overload trips shall be provided for three phases.

Motor data is shall be obtained from equipment supplier before ordering any motor starter, or motor nameplate checked for full load current rating and allowable temperature rise in order to select proper overload thermal element for motor starter.

Short circuit protection device fitted to starter shall be independent of controller and overload protection.

Control for starters and control circuits is not to exceed 220 V.

Step down control circuit transformers shall be two winding isolating type.

Control circuit protection shall be high rupturing capacity fuses or circuit breakers.

Auxiliary supply for controls, other than from main power circuit, shall be effectively isolated by auxiliary contacts on main isolator.

Control devices on starters shall be as follows unless otherwise indicated or required by driven equipment: start stop push buttons, one red pilot light for "running", one group pilot light for "stopped" and one reset push button.

Starter type A for single phase motors not exceeding 1/2 HP shall be surface or flush mounted, manual two pole toggle type, for non reversing across the line starting, fitted with one overload element.

Starter type B for three phase motors not exceeding 10 HP shall be direct on line, non reversing, magnetic type, with manual reset, 3 pole overload relay and low voltage protection, unless otherwise required by local regulations.

Starter type C for three phase motors over 10 HP, but not exceeding 50 HP, shall be automatic star delta magnetic non reversing type, with 3 pole overload relay and adjustable low voltage relay, unless otherwise required by local regulations.

Starter type D for three phase motors over 50 HP shall be multiple step auto transformer non reversing magnetic type, with 3 pole overload relay, adjustable low voltage relay, earth leakage relay and with unbalanced current protection, unless otherwise required by local regulations.

Individually mounted starters shall be totally enclosed in sheet steel enclosure with baked enamel finish. Design is to suit location and application. It is shall be impossible to open enclosure door unless isolator is in open position.

Nameplates: starters and controls shall have engraved nameplates identifying system or defining its function.

H. Isolating Switches

Isolating switches shall be non fusible, single throw type, housed in separate metallic enclosure, with arc quenching devices on each pole capable of interrupting at least six times its rated current. They are to simultaneously interrupt power supply to all line conductors, any neutral and control circuits.

Isolating switches for single phase fractional horsepower motors shall be single pole, dolly operated type, rated 15/20 A at 250 V AC, quick make, quick break, with silver alloy contacts, flush or surface mounted to suit application.

Operating mechanism shall be quick make quick break type, with external operating handle mechanically interlocked with enclosure cover to necessitate disconnecting switch shall be in OFF position for access to inside of enclosure. Means are shall be provided for by passing interlocks. Position of isolating switch shall be clearly indicated on cover.

Enclosure shall be general purpose type, unless otherwise indicated or required, with provision for locking operating handle in OPEN and CLOSED positions.

Enclosures where indicated or required by location shall be weatherproof totally sealed water and dustproof type.

J. Combination Starters Isolating Switches

Components to comprise magnetic starter, isolating switch and short circuit protection devices required by the Standards, in approved sheet metal enclosure to suit application.

Isolating switch operating mechanism quick make, quick break, with external operating handle mechanically interlocked with enclosure cover necessitating disconnecting switch shall be in OFF position for access to inside of enclosure. Means are shall be provided for by passing interlocks. Position of isolating switch shall be clearly indicated on cover.

Short circuit protection gear shall be HRC fused cartridges or moulded case circuit breakers of appropriate current rupturing capacity.

Operation of circuit breaker shall be possible from outside of enclosure. Position of breaker ON/OFF/TRIPPED shall be clearly indicated by position of handle.

K. Push Buttons

Push buttons shall be one unit momentary contact START/STOP with normally open or normally closed contacts as required by wiring diagrams and with lockout attachments. Heads shall be color coded and STOP button shall be protected. Push buttons controlling one piece of equipment shall be housed in separate enclosure.

L. Relays

Relays shall be multipole with normally open or normally closed contacts, electrically operated at 220 V maximum, and magnetically held. Contacts shall be double break, silvered type, interchangeable from normally open to normally closed without additional parts. Relays are shall be rated at 10 A, 600 V.

M. Circuit Breakers

Circuit breakers shall be thermal magnetic type, with moulded case, manually operated for normal switching functions and automatically operated under overload and short circuit conditions.

Circuit breakers to give positive trip free operation on abnormal overloads, with quick make quick break contacts under both manual and automatic operation. Stationary and movable contacts shall be non welding silver alloy adequately protected with effective and rapid arc interruption.

Branch circuit breakers shall be 100 A frame size, unless otherwise shown.

Main circuit breakers shall be 100 A frame size or larger as shown on the Drawings.

Breakers of 225 amp frame size and larger shall have interchangeable trip units and adjustable instantaneous trips unless otherwise shown.

Main incoming breakers shall be current operated, earth leakage type, or suitably equipped to provide earth fault protection. Earth fault detection and interruption shall be time coordinated with those of main incoming breaker on main distribution board.

Multiple pole breakers shall have single handle mechanism. Each pole shall have inverse time delay thermal overcurrent trip element and magnetic instantaneous overcurrent trip element for simultaneous tripping of all poles.

Trip elements shall be ambient temperature compensated type.

N. Motor Control Panels

Motor control panels shall be wall mounted or unit mounted, lockable type.

Construction shall be minimum 1.5 mm thick hot-dip galvanized steel sheet, finished with one coat etch primer and one coat stove enamel internally and externally.

Panels installed outdoors shall have weatherproof totally sealed water and dustproof enclosures.

Panels are to contain necessary breakers, starters, push button switches, selector switches, relays, indicating lights, interconnecting and interlock wiring and all devices and accessories required for automatic or manual operation of equipment as specified under equipment concerned.

Labels starters, switches, electrical devices and accessories shall be clearly labeled in English as to function and number. Labels shall be permanently fixed under each component.

Schematic and wiring diagrams shall be mounted in permanent approved manner on the inside of panel door. Diagrams are to show each component cross referenced with component labels.

P. Switches

Float switches shall be level operated, heavy duty, bracket mounted type, suitable for application in open tanks, complete with 178 mm spun copper float, brass rod, two stops, floor mounting stand, lever and counterweight. Switch shall have oil tight and dust tight enclosure and 2 pole double throw silver contacts that open on liquid rise.

Float switch shall be as manufactured by Square D, Type BW 3, or approved equal.

Pressure switch shall be industrial, heavy duty, bellows actuated type, suitable for water service, with contacts to close on falling pressure. Range shall be 0.1 to 8 kg/cm². Switch shall be good for 1720 kPa operating pressure and shall have 6 mm pipe tap bottom connection. It shall have oil tight and dust tight enclosure, single pole double throw contacts and setting adjustment.

Pressure switch shall be as manufactured by Square D Company Type ACW-1 or approved equal.

Low suction pressure switch shall be industrial, sensitive, low range, diaphragm actuated type, suitable for water service, with range of 2 to 20 kPa of falling pressure, preset at factory to 3 kPa. Switch shall be good for 690 kPa operating pressure and shall have 6 mm pipe tap bottom connection. It shall have oil tight and dust tight enclosure, single pole double throw contacts, range adjustment knob, sealing cap and range locking nut.

Low suction pressure switch shall be as manufactured by Square D Company Type AMW-1 or approved equal.

PIPE WORKS AND FITTINGS (15060)

A. General Requirements

Supply and install, wherever shown on the drawings and as specified herein, all pipe works and fittings.

All pipes shall carry the Kite Mark of the standard to which they are manufactured, clearly indicated at intervals. Pipes without the above markings shall be rejected.

Pipe works shall be installed in a manner to allow for ease of air escape and system draining. It shall be endeavoured to obtain this naturally by gravity; however, where conditions do not permit it, an automatic air vent shall be supplied and installed at all air pockets locations and a drain valve shall be supplied and installed at all low points and risers legs.

In addition to the stipulations of the above paragraph, cold and hot water pipes supplying bath rooms as well as all vertical risers shall be provided with automatic air vents and associated drain pipes.

Drainage pipes shall be installed with a slope of not less than 1% unless specifically indicated otherwise on the drawings.

Drainage pipes installed underground shall be minimum 2" diameter.

Before installing any pipe, it shall be internally cleaned from dirt, debris, etc,... by passing through it a cleaning cloth.

Pipes shall be installed in a neat manner with runs parallel and branchings or changes in direction at 90 or 45 degrees. Change in direction and size, branching and jointing of pipes shall be made with regular pipe fittings (elbows, tees, reducers etc..). Pipe bending shall not be accepted. All elbows shall be long radius. All drainage fittings shall be long radius sweep type.

Field fabricated fittings, bushings, close nipples and street elbows shall not be allowed.

Sleeves shall be supplied and installed wherever pipes cross slabs, walls, partitions, etc,... Sleeves shall be cuts of galvanized steel pipes having an internal diameter of not less than 1 1/2" (4cms) larger than the outside diameter of the bare sleeved pipe or the insulated sleeved pipe.

Floor sleeves shall protrude about 3/4" (2cms) above finished floor level and shall be flush with finished walls. Gaps between sleeves and pipes shall be filled with non-flowing plastic or waterproof mastic filler or paste.

Escutcheons shall be provided at all sleeves, when exposed to view. Escutcheons shall be chrome-plated.

Cleanouts shall be supplied and installed at all changes in direction of soil, waste and drain and rain water drain pipes.

Unions or flanges shall be provided at adequate intervals in the piping networks, as approved by the Engineer, to permit easy disassembly for alterations and repair.

Unions or flanges shall be provided at connections to equipment, near valves, controls, strainers and other accessories requiring removal.

All pipes shall be supplied and installed complete with the followings:

- a. All connections and fixings to equipment and accessories.
- b. Unions, flanges, couplings, elbows, crosses, reducers, caps, etc,...

- c. Expansion joints wherever specified or indicated on the drawings as well as all passages of pipes at structural expansion joints.
On drain and soil pipes, expansion joints shall be packing type.
Whenever soil and drain pipes are installed with elastomeric joint rings, expansion joints may be omitted after obtaining Engineer's written approval to this effect.
- d. Shock absorbers or water hammer arrestors at quick closing valves as well as automatic air vents at high points and drain valves at low points.
- e. Dielectric unions or flanges wherever copper pipes connect to ferrous pipes, or wherever dissimilar metals liable to galvanic corrosion are connected together.
- f. Metallic supports, saddles, anchors, etc,...
- g. All cutting, patching and making good of walls, slabs, partitions, etc,... in connection with fixing, supporting and anchoring of pipes within the building.
- h. All works of excavations, trenchings, back filling and making good of roads, green spaces, walkways, etc,... in connection with installing of pipes outside the building.

Buried metallic pipes shall be wrapped with corrosion protection tape or other approved type of protective cover (i.e. Denso tape or equal).

B. Pipes Material

Pipes materials shall be used shall be as follows:

- a. Galvanized steel pipe and fittings for domestic and potable water,in exposed application, and PPR random pipes where embedded in walls and under tiles.
- b. UPVC non-pressure pipe and fittings for condensate drain.
- c. UPVC non-pressure pipe and fittings for rain water drainage system pipes.
- d. UPVC non-pressure pipe and fittings for soil, waste and vent pipe systems.
- e. High density polypropylene pipes for laboratory waste piping system.
- f. Pressure UPVC pipes and fittings for sump pumps discharge pipes.
- g. Black seamless steel pipes and fittings for fire fighting water system, heating water pipes, chilled water pipes and fuel oil pipes, and CCSSD sterilizers drainage pipes.
- h. Copper pipes for medical gases, vacuum and medical compressed air systems.

C. Black Steel Pipes

Supply and install all black steel pipes as specified herein

Each black steel pipe shall conform with the following requirements:

- a. Black steel pipes shall be seamless steel medium weight conforming with DIN 2440, BS 1387 medium class or equivalent international standard for steel pipes.
- b. Pipe fittings (tees, elbows, crosses, reducers, unions, flanges, etc,...) shall be of the same weight and quality as the pipe.

- c. Pipes and fittings up to 2" shall be black malleable iron suitable for threaded connections.
- d. Pipes and fittings larger than 2" shall be black seamless suitable for welded connections.
- e. Fittings up to 2" shall be banded with threaded connections.
- f. Pipe wall thickness and weight shall be as follows:

Pipe Size (inches)	Thickness (mm)	Weight of Plain End Pipe Kg/m
1/2	2.65	1.22
3/4	2.65	1.58
1	3.25	2.44
1 1/4	3.25	3.14
1 1/2	3.25	3.61
2	3.65	5.10
2 1/2	3.65	6.51
2"	4.00	8.47
4"	4.50	12.10

D. Galvanized Steel Pipes

Supply and install all galvanized steel pipes as specified herein.

Each galvanized steel pipe shall conform with the following requirements:

- a. Galvanized steel pipes shall be seamless steel medium weight conforming with DIN 2440, BS 1387 medium class or equivalent international standard for steel pipes.
- b. Pipe fittings (tees, elbows, crosses, reducers, unions, flanges, etc,...) shall be galvanized steel of the same weight and quality as the pipe.
- c. Pipes and fittings shall be suitable for threaded connections.
- d. Polypropylene acid resistant Pipes for laboratory drainage application
- e. Fittings shall be banded with threaded connections.
- f. Pipe thickness and weight shall be same as those for corresponding black steel pipes.

E. UPVC Non-Pressure Pipes

Supply and install all UPVC pipes as specified herein.

Each UPVC pipe shall conform with the following requirements:

- a. Plastic pipes shall be extruded unplasticized PVC (UPVC) conforming to the following British Standards or approved equal, for non-pressure drainage pipes:
 - Pipes 32mm to 50mm diameter : to BS 5255. for above and under ground pipes
 - Pipes 82mm to 160mm diameter installed above ground: to BS 4514.
 - Pipes 110mm and 160mm diameter installed underground : to BS 4660.

- Pipes larger than 160mm diameter : to BS 3506.
- b. Pipe fittings shall be UPVC of the same weight and quality as the pipe.
- c. All pipes and fittings shall be marked with the Kite Mark of the standard to which they are manufactured.
- d. Unless specifically stated otherwise, pipes and fittings for drainage works shall be suitable for rubber ring pressure joint. Sealing rings shall be rubber to BS 2494 Part 2.
- e. Alternatively pipes to DIN 8061 are acceptable.

F. Pressure UPVC Pipes and Fittings

Supply and install all pressure UPVC pipes and fittings as specified herein.

- a. All pressure UPVC pipes shall be of extruded unplasticized Polyvinyl Chloride to BS 3505 class E or approved equal International Standards. Fittings shall be of same material and pressure as pipe.
- b. All joints shall be of the rubber ring pressure joint.

G. Polypropylene Pipes for domestic water

Supply and install all polypropylene pipes as specified herein:

Each polypropylene pipe shall confirm to the following requirements:

- Pipes shall be according to DIN 8078 made of polypropylene type 3. Dimensions of pipes are corresponding to DIN 8077, pipe series 6. Pipes are tested and supervised according to DIN 8075.
- Pipes joint assemblies and fittings shall be welded. Continuous working pressure up to 20 bars, continuous working temperature: up to 90°C.
- The polypropylene pipe system shall correspond to the regulations of the federal public health office.

H. Polypropylene Pipes (laboratory Drainage)

Supply and install all polypropylene pipes as specified herein:

- a. Polypropylene pipe, hot water resistant – stabilized light sensitivity durably flame resistant according to DIN standard 4102.
- b. Resistant to inorganic salts, concentrated bases and mineral acids as found in laboratory discharges. Organic solvents will not dissolve polypropylene.
- c. Color medium gray according to BAL 7037.
- d. Pipes shall bear the following permanent marks in red colors: the quality mark, the test marks, the manufacturer logo, the nominal size, the number of the standard specification DIN 19560 and the date of manufacture and the number of the extrusion line.
- e. Jointing by push-fit socket.
- f. Sealing by pre-fixed lib ring seal.

PIPE HANGERS AND SUPPORTS (15080)

A. General Requirements

- a. Supply and install pipe hangers and supports to properly carry weight of pipes and accessories without sagging as specified and required.
- b. Hangers and supports shall be designed and tested to sustain a load 8 times the actual supported load, and shall be easily adjustable.
- c. Hangers and supports shall be steel with smooth flat bearing surfaces and shall allow free movement of pipes due to expansion and contraction without any deformation. Hangers and supports for UPVC Pipes shall be of material, type and spacing strictly in accordance with manufacturers recommendations.
- d. Hangers and supports on insulated pipes shall have galvanized steel sheet protection saddles or shields, 3mm thick, 30cm long to fit outside diameter of insulation and cover 180° of arc.
- e. Pipe anchors and guides shall be 3/4" diameter U-bolt.
- f. Piping shall be independently supported of equipment and located at adequate intervals to avoid air pockets and dirt traps. All branching shall be directly supported.
- g. Spring cushions shall be used where pipe is subject to considerable vertical movement or vibration.
- h. Insulated hot pipes shall be supported on a clevis hanger or pipe clamp lined with protection shields.
- j. The contractor shall submit shop drawings for all types of supports showing construction details.
- k. Hangers and supports locations shall be shown on shop drawings.

B. Steel Pipework

Horizontal steel pipe supports shall be installed at intervals not exceeding the maximum support spacing and by hanger rod of minimum size as follows:

Pipe Diameter	Maximum Support Spacing - M	Minimum Size of Hanger Rod (mm)
1/2"	1.5	10
3/4"	1.8	10
1"	2.0	10
1 1/4"	2.5	10
1 1/2"	2.7	10
2"	3.0	10
2 1/2"	3.3	13
3"	3.6	13
4"	4.2	16
5"	4.8	16
6"	5.2	22
8" and larger	5.8	25

Vertical steel pipe supports shall be installed at a minimum of every storey height.

C. UPVC Pipework

The following shall be used as a guide line. Manufacturer's recommendations shall be strictly followed:

Pipe Diameter	Maximum Support Spacing Horizontal Pipes (cm)	Vertical Pipes(cm)	Minimum Size of Hanger Rod
1/2"	60	120	10 mm
3/4"	70	140	10 mm
1"	75	150	10 mm
1 1/4"	80	160	10 mm
1 1/2"	90	180	10 mm
2"	105	210	10 mm
3"	135	270	13 mm
4"	150	300	16 mm
6"	180	360	16 mm
8" and larger	215	360	16 mm

VALVES AND SPECIALTIES (15100)

A. General Requirements

Supply and install, wherever shown on the drawings and as specified herein, all valves and specialties.

In addition to valves proper, this section is applicable to the strainers, safety valves, automatic air vents, float valves, etc,...

The drawings indicate locations of major valves only. This does not limit the Contractor's responsibility to supply and install all valves and specialties specified separately under equipment or systems and in full compliance with the requirements of this section and the following stipulations:

- a. Valves shall be designed for a working pressure of not less than 125 psi steam working pressure rating and 200 psi cold water non-shock pressure rating unless otherwise specified.
- b. Valves 2" diameter and less for services shall be bronze, threaded ends.
- c. Valves 2 1/2" diameter and larger for services shall be cast iron, flanged ends.
- d. Unless specifically stated otherwise, valves shall be of the same size as the pipes on which they are installed.

Whenever the pipe size on which valves are shall be installed is larger or smaller than the equipment connection provided, an enlarger or reducer shall be first installed at the equipment connection to the required pipe size, after which the valves can be installed.

- e. A conical union shall be supplied and installed with each threaded valve.
- f. Install silent check valves on pump discharge pipes.

B. Gate Valves

Supply and install, wherever shown on the drawings and as specified herein, all gate valves.

Each gate valve shall conform with the following requirements:

- a. Bronze gate valves shall have bronze body and trim and shall be non-rising stem, screwed bonnet and solid wedge disc.
- b. Cast iron gate valves shall have cast iron body and shall be inside screw, non-rising stem, bolted bonnet, wedge disc and bronze trimmed.

C. Globe Valves

Supply and install, wherever shown on the drawings and as specified herein, all globe valves.

Each globe valve shall conform with the following requirements:

- a. Bronze globe valves shall have bronze body and trim and shall be inside screw, rising stem, screwed bonnet and renewable composition disc.
- b. Cast iron globe valves shall have cast iron body and shall be outside screw and yoke, rising stem, bolted bonnet, renewable bronze disc and seat ring and bronze trimmed.

D. Check Valves

Supply and install, wherever shown on the drawings and as specified herein, all check valves.

Each check valve shall horizontal or vertical lift, non-slam type and shall conform with the following requirements:

- a. Bronze check valves shall have bronze body and bronze trim and shall be screwed bonnet and renewable composition disc.
- b. Cast iron check valves shall have cast iron body and shall be bolted bonnet, renewable bronze disc and seat ring and bronze trimmed.
- c. Silent check valves 2" diameter and under shall be non-slam, spring loaded, screwed, with bronze body, seat and disc, 18-8 stainless steel spring with body having 300 psi working pressure rating.
- d. Silent check valves 2 1/2" diameter and above shall be non-slam, spring loaded, flanged, with cast iron body, bronze seat and disc, 18-8 stainless steel spring, with body having 250 psi working pressure rating.

E. Strainers

Supply and install, wherever shown on the drawings and as specified herein, all strainers.

Each strainer shall conform with the following requirements:

- a. Strainers 2" diameter and under shall be bronze body, 150 psi steam working pressure, screwed, "Y" type with 20 mesh stainless steel screen and screwed end-cleaning cap with 1/2" tapped hole for blowdown valve.
- b. Strainers 2 1/2" and larger shall be flanged, cast iron body, 125 psi steam working pressure "Y" or basket type with 20 mesh stainless steel screen and bolted end-cleaning cap with 3/4" diameter tapped hole at bottom for blow down valve.

F. Float Valves

Supply and install, wherever shown on the drawings and as specified herein, all float valves.

Each float valve shall conform with the following requirements:

- a. All bronze construction including levers and arms suitable for 150 psi cold water working pressure.
- b. Balancing piston type flow control mechanism.
- c. Adjustable bronze rod.
- d. Copper float.

G. Safety Valves

Supply and install, wherever shown on the drawings and as specified herein, all safety valves.

Each safety valve shall conform with the following requirements:

- a. Bronze body and trim, suitable for 150 psi steam working pressure.
- b. Adjustable, spring loaded relief mechanism testing arm.
- c. Spring pressure adjusted locknut.
- d. Relief outlet for piped connection.

Setting of safety valves shall be at 125% of the system operating pressure. After adjustment, the adjusting screw shall be locked by an adequate lead sealed wire.

H. Pressure Regulating Valves

Supply and install, wherever shown on the drawings and as specified herein, all pressure regulating valves.

Self contained, spring loaded suitable for inlet pressures up to 300 psi, bronze body with stainless steel springs.

Each pressure regulating valve shall be complete as specified herein:

- a. Balanced seat valve with integral strainer.
Contractor may provide pressure reducing valves with separate strainer if desired.
- b. High temperature resisting diaphragm.
- c. Spring chamber with regulating knob.
- d. Pressure gauge and gauge cock at its outlet and at its inlet.
- e. Basket strainer at its water inlet.
- f. Isolating gate valves at its inlet and outlet connections.
- g. By pass line with one isolating valve and one flow regulating globe valve.
- h. Pressure regulating valve shall provide a constant outlet pressure irrespective of variations in inlet pressure.

J. Balancing Valves

Shall be of the double regulating variable orifice, globe pattern type. It shall have a throttling disc and two pressure test points for regulation and measurement of system pressure drop and water flow. Valve handwheel shall have about 8 turns capacity between fully open and fully closed positions.

Valve body is shall be high quality bronze and bronze trim with for sizes up to 2" diameter and cast iron body with bronze trim for sizes larger than 2" diameter. Working pressure is shall be 15 bars at 150°C.

K. Expansion Joints

Supply and install, wherever necessary and as specified herein, all expansion joints.

Expansion joints shall be installed on piping to relieve expansion stresses and shall be located at all structural expansion joints and on all straight runs of pipes at 30 meters intervals.

U-bends expansion joints may be accepted under certain conditions after written Engineer's approval.

Each expansion joint shall conform with the following requirements:

- a. Packless bellows type, monel metal for pressure pipes services suitable for 150 psi steam working pressure.
- b. Packing type for gravity piped.
- c. Expansion joints shall have screwed, flanged or welding ends as required for the pipe size and system served.

L. Automatic Air Vents (AAV)

Supply and install, wherever shown on the drawings and as specified herein, all automatic air vents.

Each automatic air vent shall be completed as specified herein:

- a. Cast iron body.
- b. Standard float.
- c. Single lever orifice vent.
- d. Vent test cock.
- e. Isolating valve.

M. Hose Bibs (HB)

Supply and install, wherever shown on the drawings and as specified herein, all hose bibs.

Each hose bib shall conform with the following requirements:

- a. All brass, chrome plated construction.
- b. 3/4" threaded end connection with serrated hose bib nipple for 3/4" hose connection.

N. Water Hammer Arrestors

Supply and install, at all pipe connections to flush valves and as specified herein, all water hammer arrestors.

Each water hammer arrestor shall be complete as specified herein:

- a. Stainless steel shell and adapter.
- b. Elastomer bellows.
- c. Hydraulic displacement fluid.
- d. Pressurized insert gas pneumatic displacement chamber.
- e. 1/2" NPT threaded connection.

P. Valves Boxes

Supply and install, wherever shown on the drawings and as specified herein, all valve boxes.

Sizes and number of valves in each valve box shall be as shown on the drawings.

Each valve box shall be of masonry wall construction or metallic wall construction encased within masonry.

Each valve box shall conform with the following requirements:

- a. Depth shall conform with site conditions and pipes inverts.
- b. Valve boxes located outside shall provide a minimum cover of 30cms over pipes passing through.
- c. Indoor valve boxes shall have a steel cover matching space internal finish.
- d. Outdoor valves boxes shall be provided with a heavy duty cast iron cover, lockable type.

Q. Flexible Connections

Supply and install, wherever shown on the drawings and as specified herein, all flexible connections.

Flexible connections shall be installed on all pipe connections to rotating equipment.

Each flexible connection shall conform with the following requirements:

- a. Seamless bronze tubing with annular corrugations covered with high tensile bronze braid suitable for 200 psi cold working pressure.
- b. Screwed ends for pipes 2" diameter and smaller and flanged ends for pipes 2 1/2" diameter and larger.

INSULATION AND LAGGING (15260)

A. General Requirements

Supply and install, all insulation and lagging wherever specified in this Book of Specifications in accordance with the requirements of this section.

Insulation material shall be fiberglass.

Insulation types shall be used shall be as follows:

- a. Rigid board, fiber glass type shall be used for ducts run outdoors and for kitchen exhaust ducts.
- b. Blanket type fiber glass shall be used for equipment, ducts and flat surfaces.
- c. Rigid fibreglass pipe insulation for piped services carrying chilled, heating and hot water services.
- d. Provide insulation for the following services :
Supply and return air conditioning ducts carrying cooled or heated air,
Refrigerant suction and liquid lines.
Chilled water and heating water pipes.
Condensate drain pipes.
Domestic hot water pipes.

B. Insulation Finish

Insulation finish shall be executed as follows:

- a. Finished insulation surface shall present a neat, uniform and straight appearances, whether concealed or exposed to view.
- c. All insulation exposed on roof or to weather agents shall be provided over and above the Specification requirements with additional water proofing and weather proofing material in 3 layers, plus a final outer jacket of aluminum construction 0.8mm thick.
- d. All pipe insulation shall be finished by a factory applied vapour barrier of aluminum foil laminated on to kraft paper and reinforced with glass yarn mesh. All joints shall be sealed with sealing tape and held in place by adequate number of non-corrodible bands.

C. Acoustic Duct Liner

- a. All supply, return and exhaust air ducts shall be lined internally with fiber glass duct liner up to a minimum length of 3 meters from their connections with the air handling units and fans.
- b. Duct acoustic liner shall have one surface covered with heavy coating of black pigmented neoprene layer.
- c. Whenever acoustic liner is specified for ductworks, the duct dimensions shown on the drawings are understood shall be the net internal dimensions resulting AFTER the liner is installed.
- d. Duct lining of the operating rooms should not be used unless 90% efficient minimum terminal filters are used downstream of the linings.

D. Insulation Thicknesses

Thicknesses or insulation shall be supplied and installed for the various systems shall conform with the following table:

- a. Conditioned air supply and return: 1 1/2"
ductwork

- b. Refrigerant suction and liquid lines: 1"
- c. Condensate drain pipes: 1/2"
- d. Acoustic duct liner: 1/2"
- e. Heating and chilled water pipes up to 2" diameter: 1 1/2"
- f. Heating and chilled water pipes 2 1/2" and above: 2"
- g. Domestic hot water pipes: 1"

E. Duct Insulation - Type A

Fiberglass rigid board type of minimum density 6 lbs per cu.ft. and an average thermal conductivity not exceeding 0.25 Btu-inch per sq.ft. per degree F per hour at a mean temperature of 75° F faced with aluminum foil and Kraft paper.

F. Duct Insulation - Type B

Fiberglass blanket type of minimum density 2 lbs per cu.ft and an average thermal conductivity not exceeding 0.25 Btu-inch per sq.ft. per degree F per hour at a mean temperature of 75° F faced with aluminum foil and Kraft paper.

G. Pipe Insulation

Performed sectional rigid pipe insulation, with a thermal conductivity not exceeding 0.23 btu-inch per sq.ft. per degree F per hour at a mean temperature of 75° F, specifically supplied for the nominal pipe size. Density shall not be less than 6 lbs per ft³.

H. Insulation on Cold Equipment

Voids between insulation and equipment shall be filled with blanket insulation and cover with removable 1mm galvanized sheet metal casing panel lined with 50mm thick rigid board insulation. Vapour seal closure joints on metal casing with vapour barrier coating.

J. Insulation on Hot Equipment, Smoke Pipe and Breeching

Material shall be calcium silicate blocks suitable for high temperature. Edges of calcium silicate blocks shall be butted tightly and secured with 1.5mm thick galvanized annealed steel wire, or 15mm x 0.04mm galvanized steel bands, at 300mm centres. Cover insulation with 50mm hexagonal mesh wire tightly stretched in place with edges tied together and coat with 6mm thick coat of insulating cement trowelled smooth. Reinforce corners with 50 x 50 x 3mm iron angles. Provide cleanout doors with angle frames and insulate in same manner as equipment.

FIRE FIGHTING SYSTEM (15310)

A. Fire Hose Cabinet type FHC-1

Supply and install fire hose cabinet wherever shown on drawings and as specified herein.

- a. Fire Hose Cabinet: Recessed mounted type, with painted steel body, trim and door, finished with baked white enamel on inside and outside. Cabinet is to consist of one compartment to house a portable fire extinguisher type FE-1 and a hose rack and hose. Body and trim shall be 16 gauge and door 20 gauge thickness. Door shall have full panel double strength glass with 'FIRE HOSE' decal. Hose cabinet shall be supplied from factory with the following equipment:
 - One 1 1/4" inlet gate valve.
 - One 1" x 1" brass reducer.
 - One steel hose rack with rack nipple.
 - One 1" unlined linen fire hose, 30m long with brass hose couplings attached.
 - 1" brass nozzle.
 - One 9 kg ABC nitrogen operated dry chemical fire extinguisher.,

B. Fire Hose Cabinet Type FHC-2

Same as type FHC-1 but suitable for exposed surface mounting.

C. Portable Fire Extinguishers

Supply and install all portable fire extinguishers wherever shown on the Drawings and as specified herein:

1. Portable fire extinguishers, dry chemical type FE-1
 - a. Dry chemical "ABC" type of 9 kgs capacity.
 - b. Heavy duty drawn steel cylinder with hard, scratch-resistant red enamel finish.
 - c. All brass operating valve, large size operating lever, full vision pressure gauge and discharge hose.

Supply and install all portable fire extinguishers wherever shown on the Drawings and as specified herein:

2. Portable fire extinguishers, CO2 type FE-2
 - a. Carbon dioxide type of 9 kgs capacity.
 - b. Heavy duty drawn steel cylinder with hard scratch-resistant, enamel finish with colour as per International fire regulations colour code for CO2.
 - c. Pull-pin, squeeze handle, double braided hose and non-conducting discharge horn.

D. Automatic Fire Extinguishers

Each automatic fire extinguisher shall conform with B.S N.F, ISO 90001 regulations and shall be complete and conform with the following requirements :

- a. Extinguishing agent shall be all purpose dry chemical powder or carbon dioxide, suitable for Classes A, B, and C fires, as shown on the drawings and indicated in the specifications.
- b. Extinguisher body shall be cylindrical shape of drawn steel and tested at not less than 200kg/cm²
- c. Controllable discharge head valve, safety fracture disc., safety clip, high impact nozzle and pressure indicator gauge.

- d. Extinguisher shall be finished with red paint.
- e. Supports and/or wall brackets

Capacity of each Automatic Fire extinguisher shall be as given in the bills of quantities and as indicated on the drawings.

Extinguisher shall be ceiling mounted and shall be provided with quartz fuse and sprinklers in brass calibrated at 60°C.

E. CO₂ Automatic Fire Protection System

Supply and install CO₂ automatic fire protection system wherever shown on drawings and as specified herein.

Provide fixed total flooding CO₂ fire extinguishing system and companion fire detection system for protection of the heating plant room.

- Features
 - Non-corrosive, non-conductive, clean extinguishing agent that leaves no residue
 - Suitable for Class A, B, and C hazards
 - Fixed nozzle and/or hose reel agent distribution
 - UL, ULC, and FM approved
 - In accordance with NFPA-12 – Carbon Dioxide Extinguishing Systems

- Application

The Carbon Dioxide (CO₂) Fire Suppression System shall be an engineered system utilizing either a fixed nozzle agent distribution network, hose reel(s), or a combination of both. The system is listed by Underwriters Laboratories, Inc. (UL) and Underwriters Laboratories of Canada (ULC), and is approved by Factory Mutual (FM). The system is designed in accordance with the latest revision of the National Fire Protection Association (NFPA) Standard 12, "Carbon Dioxide Extinguishing Systems." When properly designed, the carbon dioxide system will suppress fire in Class A, B, and C hazards by displacing the air containing oxygen which supports combustion.

- Description

The CO₂ Fire Suppression System shall be actuated by detection and control equipment for automatic system operation along with providing local and remote manual operation as needed. Accessories are used to provide alarms, delay discharge, ventilation control, door closures, or other auxiliary shutdown or functions.

Due to the method of extinguishment, personnel occupying areas protected by carbon dioxide systems must be evacuated prior to system discharge. For this reason, discharge time delays and alarms are mandatory for occupied hazards. Two or more hazard areas can be protected with a single group of agent storage containers (cylinders) by means of directional or selector valves.

The CO₂ Fire Suppression System shall be particularly useful for suppressing fires in hazards where an electrically non-conductive medium is essential or desirable; where clean-up of other agents presents a problem; or where the hazard obstructions require the use of a gaseous agent.

Additional equipment includes: remote manual pull stations, corner pulleys, door closures, pressure trips, bells and sirens, transfer switches, time delays, pneumatic switches, and weighing devices. All or some are required when designing a total system.

- Specifications

- Part 1 – General

- Description of work:

- Design and installation shall be an engineered fire detection and carbon dioxide total flooding, gaseous agent, fire suppression system.
 - Drawings: The contract drawings shall indicate the general arrangements of the areas to receive detection and carbon dioxide protection. Contractor is to review all drawings so that all items affecting the operation of the fire detection/carbon dioxide suppression system (such as equipment location, air diffusers, damper closures, and door openings) are considered in the design of the engineered system.

- References:

- National Fire Protection Association (NFPA):
 - a) NFPA 12 – Standard on Carbon Dioxide Extinguishing Systems
 - b) NFPA 70 – National Electrical Code
 - c) NFPA 72 – Standard For Protective Signaling Systems
 - Underwriters Laboratories, Inc. (UL) and Underwriters Laboratories of Canada (ULC) – Fire Protection Equipment Directory
 - Factory Mutual (FM) Approval Guide
 - Requirements of the Authority Having Jurisdiction (AHJ)

- Requirements:

- This installation shall be made in strict accordance with the drawings, specifications and applicable National Fire Protection Association Standards. All equipment and devices used shall be listed in both the UL/ULC Fire Equipment Directory and the Factory Mutual Approval Guide.
 - Design and installation of the fire detection/carbon dioxide suppression system shall be in strict accordance with the following guidelines and regulatory agencies:
 - a) NFPA 12 – Carbon Dioxide Extinguishing Systems
 - b) NFPA 70 – National Electric Codes
 - c) NFPA 72 – National Fire Alarm Code

- General:

- Furnish all engineering designs and materials for a complete fire detection/carbon dioxide suppression system, including: charged carbon dioxide storage cylinders, nozzles, control panel, detectors, wiring, annunciators, alarms, and all other equipment necessary for a complete operational system.
- Major system components shall be installed by an authorized distributor certified for the design, installation, and service of carbon dioxide suppression systems.

Part 2 – Products

- System description and operation

- Design Requirements:
 - a) System design shall be total flood providing a minimum of 34% design concentration throughout the entire protected area.

OR

Specify the design concentration or the area of coverage if used as a local application.

- Sequence of operation:

- Activation of any single detector in any detection zone shall:
 - a) Cause audio and visual pre-discharge alarms to operate.
 - b) Transmit an alarm signal to remote monitoring or building alarm panel.
 - c) Operate auxiliary contacts for HVAC shutdowns and automatic dampers
 - d) Initiate a mechanical/pneumatic time delay to sound prior to CO2 release.
- Upon completion of the time delay the carbon dioxide system shall:
 - a) Cause a discharge alarm to be activated.
 - b) Energize control actuator for carbon dioxide cylinders releasing CO2.

- Control panel – autopulse control system:

- The control panel shall be an AUTOPULSE system and shall communicate with and control the following types of equipment used to make up the system: heat detectors, manual release, alarm notification appliances, releasing components and other system controlled devices.

- Heat detectors:

- Rate compensated heat detectors shall be supplied. Maximum spacing shall be 250 ft² (23.3 m²) per detector.

- Indicating appliances:

- Explosion-proof horn shall be provided in protected area.

OR

Alarm horn strobe shall be provided in protected area.

- Manual pull station:

- Explosion-proof manual pull station shall be provided at each exit.

OR

Manual pull station shall be provided at each exit.

- Carbon Dioxide Storage Cylinders:

- Cylinder Assembly:

- a) Steel construction with red epoxy finish and equipped with a pressure seat-type CV-98 valve.

- b) Cylinder sizes shall be 35 lb (15.9 kg), 50 lb (22.7 kg), 75 lb (34.0 kg), 100 lb (45.4 kg), or 120 lb (54.4 kg) capacity.

- Pneumatic Time Delay:

- Pneumatic time delay shall be provided to delay discharge of carbon dioxide.
- Pneumatic pressure operated siren shall be located in protected space to sound for 30 seconds prior to discharge.

- Supervised Mechanical Lockout:

- Installer shall provide a supervised mechanical lockout valve installed in the discharge line to prevent discharge of CO2 into the protected space. Control panel must display a supervisory signal when valve is closed.

- Cylinder Bracket:

- Each cylinder assembly shall be furnished with a bracket made from welded steel. The bracket shall hold the cylinders in a saddle with a front bracket piece that secures the cylinders.

The brackets shall be modular in design to allow added bracketing or stacking of cylinders depending on installation requirements.

- Cylinder brackets shall be UL/ULC listed and/or FM approved for use with the carbon dioxide.

- Valve Actuators:

- Electric valve actuators shall be of brass construction and stackable design with swivel connections to allow removal of actuators for maintenance or testing.

- Discharge Hose/Check Valve:

- When manifolding, all cylinder assemblies shall include a flexible discharge hose and check valve for connection to the manifold inlet.
- All hose/check valves shall be UL/ULC listed and/or FM approved for use with the CV-98 carbon dioxide.

- Discharge Nozzles:

- Designed to direct discharge of carbon dioxide in a liquid or gaseous state.

- Orifice size determined by flow rate and system design required.
- Standard nozzles to be natural brass or painted red.

Part 3 – System Testing

- System Checkout:

- The completed installation shall be inspected by factory authorized and trained personnel. The inspection shall include a full operational test of all components per the equipment manufacturer's recommendations.
- Inspection shall be performed in the presence of the owner's representative, Engineer or engineer's representative, insuring authority and/or the local authority having jurisdiction.
- All mechanical and electrical components shall be tested according to the manufacturers recommended procedure to verify system integrity.
- Inspection shall include a complete checkout of the detection/control system and certification of cylinder contents. A written report shall be filed with the owner.
- As-built drawings shall be provided by the contractor (two copies) indicating the installation details. All routing of piping, electrical conduit, and accessories shall be noted.
- Equipment installation and maintenance manuals shall be provided in addition to the as-built drawings.
- Prior to final acceptance, the contractor shall provide operational training in all concepts of the system to the owner's key personnel. Training shall consist of:
 - a) Control system operation
 - b) Trouble procedures
 - c) Abort procedures
 - d) Emergency procedures
 - e) Safety requirements
 - f) Demonstration of the system (excluding carbon dioxide release)
- The quantity of agent shall reflect the actual design quantity of carbon dioxide agent.
- A functional test shall be completed consisting of detection, release, alarm, accessories related to the system, control unit and a review of the cylinders, piping, fittings and cylinder pressure.

F. Kitchen Fire Fighting System

Supply and install kitchen fire system as specified

An automatic fire fighting system shall be provided for the kitchen equipment, and shall be complete and conform with the following requirements :

- Part 1 – General
- References
 - Underwriters Laboratories, Inc. (UL)

- a. UL Standard 1254
- b. UL Standard 300
- Underwriters Laboratories of Canada (ULC)
 - a. ULC/ORD-C 1254.6
- National Fire Protection Association (NFPA)
 - a. NFPA 96
 - b. NFPA 17A

- Submittals

- Submit two sets of manufacturer's data sheets
- Submit two sets of piping design drawings

- System Description

- The system shall be an automatic fire suppression system using a wet chemical agent for grease related fires.
- The system shall be capable of suppressing fires in the following areas associated with cooking equipment: ventilating equipment including hoods, ducts, plenums, and filters; fryers; griddles and range tops; upright, natural charcoal, or chain-type broilers; electric, lava rock, mesquite or gas-radiant char-broilers.
- The system shall be the pre-engineered type having minimum and maximum guidelines established by the manufacturer and listed by Underwriters Laboratories, Inc. (UL).
- The system shall be installed and serviced by personnel trained by the manufacturer.
- The system shall be capable of protecting cooking appliances by utilizing either dedicated appliance protection and/or overlapping appliance protection.

- Quality Control

- Manufacturer: The Kitchen Fire Suppression System shall be manufactured by a company with at least thirty years experience in the design and manufacture of pre-engineered fire suppression systems. The manufacturer shall be ISO 9001 registered.
- Certificates: The wet agent shall be a specially formulated, aqueous solution of organic salts with a pH range between 7.7 – 8.7, designed for flame knockdown and foam securement of grease-related fires.

- Warranty, Disclaimer, and Limitations

- The pre-engineered restaurant fire suppression system components shall be warranted for five years from date of delivery against defects in workmanship and material.

- Delivery

- Packaging: All system components shall be securely packaged to provide protection during shipment.

- Environmental Conditions

- The R-102 system shall be capable of operating in a temperature range of 32 °F to 130 °F (0 °C to 54 °C).

- Part 2 – Product

- Components

- The basic system shall consist of a regulated release assembly which includes a regulated release mechanism and a wet chemical storage tank housed within a single enclosure. Nozzles, blow-off caps, detectors, cartridges, agent, fusible links, and pulley elbows shall be supplied in separate packages in the quantities needed for fire suppression system arrangements. Additional equipment shall include remote manual pull station, mechanical and electrical gas valves, pressure switches, and electrical switches for automatic equipment and gas line shut-off.
 - Wet Chemical Agent: The extinguishing agent shall be a specially formulated, aqueous solution of organic salts with a pH range between 7.8 – 8.2, designed for flame knockdown and foam securement of grease related fires.
 - Agent Tank: The agent tank shall be installed in a stainless steel enclosure or wall bracket. The tank shall be constructed of stainless steel. Tanks shall be available in two sizes; 1.5 gallon (5.7 L) and 3.0 gallon (11.4 L). The tanks shall have a working pressure of 110 psi (7.6 bar), a test pressure of 330 psi (22.8 bar), and a minimum burst pressure of 600 psi (41.4 bar). The tank shall include an adaptor/tube assembly containing a burst disc union.
 - Regulated Release Mechanism: The regulated release mechanism shall be a spring-loaded, mechanical/pneumatic type capable of providing the expellant gas supply to one or two agent tanks depending on the capacity of the gas cartridge used. It shall contain a factory installed regulator deadset at 110 psi (7.6 bar) with an external relief of approximately 180 psi (12.4 bar). It shall have the following actuation capabilities: automatic actuation by a fusible link detection system and remote manual actuation by a mechanical pull station. The regulated release mechanism shall contain a release assembly, regulator, expellant gas hose, and agent storage tank housed in a stainless steel enclosure with cover. The enclosure shall contain knock-outs for 1/2 in. conduit. The cover shall contain an opening for a visual status indicator. It shall be compatible with mechanical gas shutoff devices; or, when equipped with a field or factory-installed switch, it shall be compatible with electric gas line or appliance shutoff devices.
 - Regulated Actuator Assembly: When more than two agent tanks are required, the regulated actuator shall be available to provide expellant gas for additional tanks. It shall be connected to the cartridge receiver outlet of the regulated release mechanism providing simultaneous agent discharge. The regulator shall be deadset at 110 psi (7.6 bar) with an external relief of approximately 180 psi (12.4 bar). The regulated actuator assembly shall contain a regulated actuator, regulator, expellant gas hose, and agent tank housed in a stainless steel enclosure with cover. The enclosure shall contain knockouts to permit installation of the expellant gas line.
 - Discharge Nozzles: Each discharge nozzle shall be tested and listed with the R-102 system for a specific application. Nozzles tips shall be stamped with the flow number designation (1/2, 1, 2, and 3). Each nozzle shall have a metal or rubber blow-off cap to keep the nozzle tip orifice free of cooking grease build-up.

- Distribution Piping: Distribution piping shall be Schedule 40 black iron, chrome-plated, or stainless steel pipe conforming to ASTM A120, A53, or A106.
- Detectors: The detectors shall be the fusible link style designed to separate at a specific temperature.
- Cartridges: The cartridge shall be a sealed steel pressure vessel containing either carbon dioxide or nitrogen gas. The cartridge seal shall be designed to be punctured by the releasing device supplying the required pressure to expel wet chemical agent from the storage tank.
- Agent Distribution Hose: Kitchen appliances manufactured with or resting on casters (wheels/rollers), which have the Fire Suppression System hard piped, shall include a UL Listed agent distribution hose as a component of the suppression system. This shall allow the appliance to be moved for cleaning purposes without disconnecting the appliance fire suppression protection. Hose assembly shall include a restraining cable kit to limit the appliance movement within the range (length) of the flexible hose.
- Flexible Conduit: The manufacturer supplying the Restaurant Fire Suppression System shall offer flexible conduit as an option to rigid EMT conduit for the installation of pull stations and/or mechanical gas valves. The flexible conduit shall be UL Listed and include all approved components for proper installation.
- Pull Station Assembly: The Fire Suppression System shall include a remote pull station for manual system actuation. The pull station shall be designed to include a built-in guard to protect the pull handle. The pull station shall also be designed with a pull handle to allow for three finger operation and shall be red in color for quick visibility.
- Part 3 – Implementation
 - Installation
 - The fire suppression system shall be designed, installed, inspected, maintained, and recharged in accordance with the manufacturer's listed instruction manual.
 - Training
 - Training shall be conducted by representatives of the manufacturer.

G. Fire Water Hydro-Pneumatic Pressure Set

Supply and install all fire water hydro-pneumatic pressure sets wherever shown on the drawings and as specified herein.

Fire water pressure set shall be pneumatic, packaged type, duplex type, complete with pneumatic pressure tank, interconnecting piping, fittings, controls, specialties and control panel for duplex operation all mounted on the same steel frame with heavy gauge steel protective casing, and all factory assembled and tested.

The set shall consist of two pumps with one pump as standby.

Fire water pressure set shall be complete as specified in the following clauses:

1. Pumps

Each pump shall be centrifugal, vertical split case, single or multistage, silent type, complete with flexibly coupled electric motor and couplings. The pump and motor assembly shall be mounted on a steel bed plate with an approved vibration isolator.

Pumps construction shall be cast iron body, volute bronze impeller, stainless steel shaft and mechanical seal.

Pumps shall be flexibly coupled to the electric motor thru a flexible coupling. Motor speed not to exceed 2900 rpm.

Each pump shall include:

- a. Casing drain and vent plugs.
- b. Gauge tappings.
- c. Drip Chamber or tray with drain connection.
- d. Gate valve and strainer at its suction.
- e. Silent check valve and gate valve at its discharge.
- f. Pressure switches.
- g. Pressure gauge and gauge cock at its discharge.
- h. Reinforced type flexible connectors at pump's suction and discharge.

2. Hydro-Pneumatic Pressure Tank

Each pressure tank shall be cylindrical or spherical, closed type, constructed in compliance with an approved international code for unfired pressure vessels.

Each pneumatic pressure tank shall include:

- a. An inert gas chamber.
- b. Flexible butyl or neoprene membrane separating the inert gas chamber from water.
- c. Air recharge valve if tank is not permanently charged at factory.
- d. Pressure gauge and gauge cock.
- e. Gate shut-off valve.

3. Capacity

Capacity of each Fire water pressure set shall be as given in the schedules of capacities and/or the Bills of Quantities.

H. Fire Water Pressure Set Operation and Control

Supply and install for each Fire water pressure set a system control and control panel which shall include all necessary pressure switches, pressure regulating valves, instruments, operating relays, safety relays as well as cables, wires, etc,... connecting it to the corresponding pump and storage tank or reservoir to obtain the following functions:

- a. When line pressure drops, the pump shall operate and remain in operation until flow stops or the pressure switch reaches its high limit setting. A minimum run-time relay, adjustable type shall be provided to prevent frequent on/off operation. If pressure drops below a preset value, the second pump shall operate.
- b. When suction water level drops to 10 cms above top of suction pipe, the pump shall stop by the action of a low level float switch; it shall not be able to run even if other controls call for its operation.

After water level rises to 15 cms above suction pipe, controls shall allow pump operation again.

- c. If operating pump fails to start the second pump shall operate automatically.
- d. An automatic sequencing control shall be provided to operate pumps in a rotational sequence after each cycle.
- e. Panel shall be provided with OFF-MANUAL-AUTO selector switch to allow the system shall be stopped and/or put on manual or automatic operation.
- f. Panel shall be provided with an alarm buzzer and switch which shall be put in operation in case of fault.
- g. For each function specified with the panel, a pilot light shall be provided to indicate the status of the particular function. Pilot lights colours shall be selected in accordance with the function shall be indicated.
- h. A delay relay shall be incorporated within the panel to prevent immediate start-up upon re-establishment of power after power failure.

DOMESTIC COLD WATER SUPPLY (15410)**A. Water lifting set**

Supply and install water lifting set wherever shown on the drawings and as specified herein.

Water lifting set shall consist of two pumps with one pump as stand-by

1. Pumps

Each pump shall be of the horizontal multistage centrifugal, silent type, complete with flexible coupled electric motor and couplings. The pump and motor assembly shall be mounted on a steel bed plate with an approved vibration isolator.

Pumps construction shall be cast iron body, volute bronze impeller, stainless steel shaft and mechanical seal.

Pumps shall be flexibly coupled to the electric motor through a flexible coupling with coupling guard. Motor shall be of the totally enclosed fan cooled type.

Each pump shall include:

- a. Casing drain and vent plugs.
- b. Gauge tappings.
- c. Drip chamber or tray with drain connection.
- d. Gate valve and strainer at its suction.
- e. Silent check valve and gate valve at its discharge.
- f. Pressure gauge and gauge cock at its discharge and suction.
- g. Reinforced type flexible connectors at pump's suction and discharge.

2. Capacity

Capacity shall be as given in the schedules of equipment.

B. Lifting Pumps set Operation and Control

Supply and install for each house lifting pump a system control and control panel which shall include all necessary switches, instruments, operating relays, safety relays as well as cables, wires, etc,... connecting it to the corresponding pump and storage tank or reservoir to obtain the following functions:

- a. When water level in the roof tanks drops below a predetermined level, the lead pump shall operate by a signal from float switches in the roof tanks, and remain in operation until the water level resumes its pre-set level.
- b. When suction water level drops to 5cms above top of suction pipe, the pump shall stop by the action of a low level float switch; it shall not be able to run even if other controls call for its operation.
After water level rises to 10 cms above suction pipe, controls shall allow pump operation again.
- c. If operating pump fails to start, the second pump shall operate automatically.
- d. An automatic alternating switch shall be provided to alternate pumps function after each cycle.
- e. Panel shall be provided with OFF-MANUAL-AUTO selector switch to allow the system shall be stopped and/or put on manual or automatic operation.
- f. Panel shall be provided with an alarm buzzer and switch which shall be put in operation in case of fault.

- g. For each function specified with the panel, a pilot light shall be provided to indicate the status of the particular function. Pilot lights colours shall be selected in accordance with the function shall be indicated.

C. Concrete Water Tanks

Supply and install of the basement reservoir the followings:

- a. Balancing piston type float valve with shut-off valve.
- b. Low level float switches assemblies as required and as necessary for the control of the relevant systems.
- c. High water level alarm float switches.
- d. Drain valve.
- e. Drain and overflow to nearest drain provision or as shown on the drawings and vent pipes with insect copper mesh screen.

Testing kit : Softener is shall be supplied with one standard water testing kit to enable operator to make determination necessary in controlling operation of softener and with batch of standard soap solution for testing sufficient for one year of operation.

D. Irrigation Water Hydro-Pneumatic Pressure Set

Supply and install all irrigation water hydro-pneumatic pressure sets wherever shown on the drawings and as specified herein.

Irrigation water pressure set shall be pneumatic, packaged type, duplex type, complete with pneumatic pressure tank, interconnecting piping, fittings, controls, specialties and control panel for duplex operation all mounted on the same steel frame with heavy gauge steel protective casing, and all factory assembled and tested.

The set shall consist of two pumps with one pump as standby.

Irrigation water pressure set shall be complete as specified in the following clauses:

1. Pumps

Each pump shall be centrifugal, vertical split case, single or multistage, silent type, complete with flexibly coupled electric motor and couplings. The pump and motor assembly shall be mounted on a steel bed plate with an approved vibration isolator.

Pumps construction shall be cast iron body, volute bronze impeller, stainless steel shaft and mechanical seal.

Pumps shall be flexibly coupled to the electric motor thru a flexible coupling. Motor speed not to exceed 2900 rpm.

Inter connecting pipes within the pumping set shall be copper pipes.

Each pump shall include:

- a. Casing drain and vent plugs.
- b. Gauge tappings.
- c. Drip Chamber or tray with drain connection.
- d. Gate valve and strainer at its suction.
- e. Silent check valve and gate valve at its discharge.
- f. Pressure switches.
- g. Pressure gauge and gauge cock at its discharge.
- h. Reinforced type flexible connectors at pump's suction and discharge.

2. Hydro-Pneumatic Pressure Tank

Each pressure tank shall be cylindrical or spherical, closed type, constructed in compliance with an approved international code for unfired pressure vessels.

Each pneumatic pressure tank shall include:

- a. An inert gas chamber.
- b. Flexible butyl or neoprene membrane separating the inert gas chamber from water.
- c. Air recharge valve if tank is not permanently charged at factory.
- d. Pressure gauge and gauge cock.
- e. Gate shut-off valve.

3. Capacity

Capacity of each irrigation water pressure set shall be as given in the schedules of capacities and/or the Bills of Quantities.

E. Irrigation Water Pressure Set Operation and Control

Supply and install for each irrigation water pressure set a system control and control panel which shall include all necessary pressure switches, pressure regulating valves, instruments, operating relays, safety relays as well as cables, wires, etc,... connecting it to the corresponding pump and storage tank or reservoir to obtain the following functions:

- a. When line pressure drops, the pump shall operate and remain in operation until flow stops or the pressure switch reaches its high limit setting. A minimum run-time relay, adjustable type shall be provided to prevent frequent on/off operation. If pressure drops below a preset value, the second pump shall operate.
- b. When suction water level drops to 10 cms above top of suction pipe, the pump shall stop by the action of a low level float switch; it shall not be able to run even if other controls call for its operation.
After water level rises to 15 cms above suction pipe, controls shall allow pump operation again.
- c. If operating pump fails to start the second pump shall operate automatically.
- d. An automatic sequencing control shall be provided to operate pumps in a rotational sequence after each cycle.
- e. Panel shall be provided with OFF-MANUAL-AUTO selector switch to allow the system shall be stopped and/or put on manual or automatic operation.
- f. Panel shall be provided with an alarm buzzer and switch which shall be put in operation in case of fault.
- g. For each function specified with the panel, a pilot light shall be provided to indicate the status of the particular function. Pilot lights colours shall be selected in accordance with the function shall be indicated.
- h. A delay relay shall be incorporated within the panel to prevent immediate start-up upon re-establishment of power after power failure.

F. Irrigation Box and Tap

Supply and install irrigation box and tap wherever shown on the drawings and as specified herein.

Unit shall be cast bronze with satin finish face and "Nikaloy" box complete with hinged latching cover with lock of vandal proof construction, and with 3/4" bronze tap with standard hose connection, control key, and with an integral extension of suitable length to connect to the buried main pipe.

G. Polyethelene water storage tanks

Supply and install Polyethelene water storage tanks wherever shown on the drawings and as specified herein.

Unit shall be polyethylene cylinder shape, triple layer, as manufactured by NTG or approved equal. The tank shall include the required connectons as shown on the drawings.

POTABLE WATER SUPPLY (15415)**A. Potable Water Hydro-Pneumatic Pressure Set**

Supply and install potable water hydro-pneumatic pressure set wherever shown on the drawings and as specified herein.

potable water pressure set shall be pneumatic, packaged type, triplex type, complete with pneumatic pressure tank, interconnecting piping, fittings, controls, specialties and control panel for triplex operation all mounted on the same steel frame with heavy gauge steel protective casing, and all factory assembled and tested.

Potable water pressure set shall be complete as specified in the following clauses:

1. Pumps

Each pump shall be centrifugal; vertical split case, single or multistage, silent type, complete with flexibly coupled electric motor and couplings. The pump and motor assembly shall be mounted on a steel bed plate with an approved vibration isolator.

Pumps construction shall be cast iron body, volute bronze impeller, stainless steel shaft and mechanical seal.

Pumps shall be flexibly coupled to the electric motor thru a flexible coupling. Motor speed not to exceed 2900 rpm.

Inter connecting pipes within the pumping set shall be copper pipes.

Each pump shall include:

- a. Casing drain and vent plugs.
- b. Gauge tappings.
- c. Drip Chamber or tray with drain connection.
- d. Gate valve and strainer at its suction.
- e. Silent check valve and gate valve at its discharge.
- f. Pressure switches.
- g. Pressure gauge and gauge cock at its discharge.
- h. Reinforced type flexible connectors at pump's suction and discharge.

2. Hydro-Pneumatic Pressure Tank

Each pressure tank shall be cylindrical or spherical, closed type, constructed in compliance with an approved international code for unfired pressure vessels.

Each pneumatic pressure tank shall include:

- a. An inert gas chamber.
- b. Flexible butyl or neoprene membrane separating the inert gas chamber from water, and suitable for drinking water applications.
- c. Air recharge valve if tank is not permanently charged at factory.
- d. Pressure gauge and gauge cock.
- e. Gate shut-off valve.

3. Capacity

Capacity of each potable water pressure set shall be as given in the schedules of capacities and/or the Bills of Quantities.

B. Potable Water Pressure Set Operation and Control

Supply and install for the potable water pressure set a system control and control panel which shall include all necessary pressure switches, pressure regulating valves, instruments, operating relays, safety relays as well as cables, wires, etc,... connecting it to the corresponding pump and storage tank or reservoir to obtain the following functions:

- a. When line pressure drops, the pumps shall operate by cascade and remain in operation until flow stops or the pressure switch reaches its high limit setting. A minimum run-time relay, adjustable type shall be provided to prevent frequent on/off operation. If pressure drops below a preset value, the second pump shall operate, and if the pressure continues to drop, the third pump shall operate.
- b. When suction water level drops to 10 cms above top of suction pipe, the pumps shall stop by the action of a low level float switch; it shall not be able to run even if other controls call for its operation.

After water level rises to 15 cms above suction pipe, controls shall allow pumps operation again.

- c. If operating pump fails to start the second pump shall operate automatically.
- d. An automatic alternating switch shall be provided to alternate pumps function after each cycle.
- e. Panel shall be provided with OFF-MANUAL-AUTO selector switch to allow the system shall be stopped and/or put on manual or automatic operation.
- f. Panel shall be provided with an alarm buzzer and switch which shall be put in operation in case of fault.
- g. For each function specified with the panel, a pilot light shall be provided to indicate the status of the particular function. Pilot lights colours shall be selected in accordance with the function shall be indicated.
- h. A delay relay shall be incorporated within the panel to prevent immediate start-up upon re-establishment of power after power failure.

C. The Electric Panel Board

The Contractor shall supply an electrical panel board including:

- A main disconnecting link
- One circuit breaker and a number of starters for each pump
- All necessary relays
- Protection for the control equipment
- One voltmeter and one ammeter.

D. Hot Water Circulating Pump Set Operation and Control

Supply and install, wherever shown on the drawings and as specified herein, hot Water Circulating Pump Set Operation and Control , composed of duplex pump set

Each pump shall be of the centrifugal, in-line, single stage type, complete with direct coupled electric motor and couplings suitable for handling water at 200°F (93°C).

The pump and motor assembly shall be flexibly coupled with spring-type vibration isolators.

Pump connections may be either threaded or flanged.

Circulators shall be horizontal or vertical all-bronze with stainless steel shaft and water tight mechanical seals. Motor shall be sleeve type bearing, drip proof, with built-in automatic thermal overload protection.

Circulators shall be complete with switch, pilot light and electrical wiring adjustable immersion type thermostats shall be furnished and installed for each pump to start and stop the pump and maintain its thermostat setting.

Pump shall be designed for operation mounted on the pipe and circulating water in any direction up, down or horizontally

Each pump Shall be supplied complete with :

- Casing drain and vent plugs
- Gauge tappings
- Gate valve and strainer at its suction
- Gate valve and check valve at its discharge.
- Reinforced flexible joints at its suction and discharge
- Built-in thermal overload motor protection
- Capacity and type of each central heating water pump shall be as given in the schedules of capacities and/or the bills of quantities.

Supply and install for each Hot Water Circulating Pump set a system control and control panel which shall include all necessary pressure switches, instruments, thermostat, operating relays, safety relays as well as cables, wires, etc,... connecting it to the corresponding pump to obtain the following functions:

- If water return temperature drops below the selected temperature, the circulating pump starts, to reach the stop preset temperature.
- If operating pump fails to start the second pump shall operate automatically.
- An automatic sequencing control shall be provided to operate pumps in a rotational sequence after each cycle.
- Panel shall be provided with OFF-MANUAL-AUTO selector switch to allow the system to be stopped and/or put on manual or automatic operation.
- Panel shall be provided with an alarm buzzer and switch which shall be put in operation in case of fault.
- For each function specified with the panel, a pilot light shall be provided to indicate the status of the particular function. Pilot lights colours shall be selected in accordance with the function to be indicated.

A delay relay shall be incorporated within the panel to prevent immediate start-up upon re-establishment of power after power failure

DRAINAGE (15420)**A. Submersible Sewage Sump Pumps**

Supply and install all sewage sump pumps wherever shown on the drawings and as specified herein.

Sump pumps shall be duplex assembly complete as specified in the following clauses:

1. Pumps

Each pump shall be of the non-clog, centrifugal, submersible, type designed for pumping raw sewage and complete with:

- a. Cast iron casing.
- b. Open type cast iron non-clog impeller able to pass solids up to 3 inches diameter.
- c. Stainless steel shaft.
- d. Mechanical seal.
- e. Water cooled, totally enclosed electric motor, rated for continuous duty. Motor speed shall not exceed 1450 rpm. Motor shall have thermal overload protection and moisture sensing probes, pump and motor bearings shall be heavy duty, permanently lubricated and sealed ball bearings guaranteed for a minimum of 100,000 hours continuous operation.
- f. Oil casing.
- g. Cables and floats fixing frame.
- h. One check valve and one gate valve at pump outlet.
- j. Air tight access cover and frame.
- k. Level regulators of the pear-shaped type.

Sump pumps shall be installed in a concrete pit shall be constructed by the Concretor.

The Contractor shall coordinate his piping with the Concretor and shall install all pipes connected to the sumps pit in accordance with the layouts shown on the drawings.

It shall be his responsibility to coordinate and determine pipes inverts and locations of pipe connections to the pit.

2. Controls

An automatic operating and control panel shall be provided for sump pumps operation.

The panel shall be of light alloy construction, perfectly sealed against dust and water and shall house pumps starters, breakers, floats, relays, interlocks, pilot lights, cables, wires, etc,... to obtain to following results:

- a. At low water level in the collecting pit, controls shall be inoperative.
- b. When water level rises to the first normal level in the collecting pit, the lead pump shall start.
- c. When water level rises to the second normal level in the collecting pit, the second pump shall start.
- d. When water level drops to the first level, the last pump to start shall stop. The first pump shall keep on running until water level drops to the low water level setting.
- e. An automatic alternating relay shall alternate pumps lead role after each cycle.

- f. Should the water level rise to the alarm preset level, controls shall act to operate an alarm bell which shall remain in operation until put off manually.
 3. Capacity
Capacity of each sump pump shall be as shown on the drawings.

B. PVC Floor Drains - Type FD-1

Supply and install all floor drains wherever shown on the drawings and as specified herein.
Each floor drain shall be constructed of heavy duty UPVC and shall conform with the following requirements:

- a. Integral trap with cleaning plug.
- b. Adjustable level, heavy duty, large grate area, stainless steel or chrome plated bronze strainer, 200mm x 200mm fixed onto the drain body.

C. Cast Iron floor drains

Supply and install wherever shown on the drawings floor drains of sizes and shapes as indicated on the drawings.

Each floor shall be of cast iron with 'S' or 'P' trap complete with chrome plated heavy duty bronze strainer fixed by screwing into the drain body. Drain shall receive two coats of asphaltic paint before installation or shall be asphalt painted at factory.

The open area of the strainer shall be at least two-thirds of the cross section area of the drain line to which it connects.

Each floor drain shall have a minimum water seal of 50mm

All floor drains shall have removable chrome plated covers over their strainers.

D. Roof Drains (RD), Terrace Drains (TD), Trench Drains (TRD), Flower Bed Drains (FBD), Garage Drains (GD) and Balcony Drains (BD)

Supply and install all roof drains, terrace drains and trench drains wherever shown on the drawings and as specified herein.

Drains shall be used on all horizontal surfaces exposed to rain water i.e. roofs, terraces, etc...

1. Roof Drain - Type RD-1

Each roof drain shall be constructed of heavy duty UPVC with bottom outlet and shall conform to the following requirements:

- a. Large grate area body with no trap and with gravel guard.
- b. Adjustable heavy duty elevated dome type strainer.
- c. Integral flashing flange.

2. Roof Drain - Type RD-2

Each roof drain shall be constructed of heavy duty UPVC with side outlet and shall conform to the following requirements:

- a. Large grate area body with no trap and with gravel guard.
- b. Adjustable level, heavy duty elevated dome type strainer.
- c. Side outlet to suit installation in shallow finish height.
- d. Integral flashing flange

E. Clean-Outs

Supply and install all clean-outs wherever shown on the drawings and as specified herein.

Each clean-out shall be of the same material and dimension as the pipe shall conform with the following requirements:

- a. For pipes exposed or in false ceilings, clean-outs shall consist of a threaded cap screwed onto pipe end.
- b. Floor clean-outs shall consist off capped wide elbows ending under a chrome plated bronze tile 20 x 20cms with screwed cover.

F. Roof Vents and Vent Caps

Supply and install all roof vents and vent caps wherever shown on the drawings and as specified herein.

Each roof vent and vent cap shall be of UPVC and conforming with the following requirements:

- a. Vent shall be full size of stack connected to it and provided with cap. Side openings shall be provided with plastic insect mesh screen securely fixed onto body.
- b. Vent shall be provided with an extension nipple for fixing onto the vented stack.

G. Grease trap Collector

Supply and install wherever shown on the drawings grease trap of size and capacity as indicated on the drawings.

Grease trap shall be of fabricated steel construction with interior acid resistance epoxy coating and shall be complete with the following :

- Visible double wall trap seal with removable pressure equalizing/flow diffusing baffle and sediment container.
- Bronze cleanout plug
- Internal air relief bypass
- Threaded inlet and outlet pipe connections
- Gas and water tight gasketed cover secured with recess and covered center securing handle.

H. Oil Interceptor

Supply and shown wherever shown on the drawings, oil interceptor of size and capacities as indicated on the drawings and/or bill of quantities.

Oil interceptor shall be of fabricated steel construction with interior and exterior acid resistance epoxy coating and shall be complete with the followings:

- Air relief by-pass.
- Bronze cleanout plug and visible double wall trap seal.
- Removable combination pressure equalizing flow diffusing baffle, and sediment bucket, horizontal baffle, adjustable oil drawoff and vent connections either side.
- Secured gasketed non-skid secured cover complete with flow control fitting.
- The oil interceptor must be able to handle a flow rate 95 m³/h.

I. Manholes Inspection Chambers and Gullies

- a. Coatings
 - Pitch epoxy coating for internal surfaces of manholes.
 - Asphaltic composition coating for external surfaces of manholes.
- b. Components
 - Precast units : to BS 5911, sections C and D, plain and reinforced concrete class C and B respectively. Cement is shall be ordinary Portland cement.
 - Cast in situ units : plain and reinforced concrete as per specifications for "Structural Works".
 - Covers and Frames for manholes : to BS 497, coated, locking, solid top. Types shall be heavy duty grade A.
 - Road Gully Gratings and sidewalk gullies: to BS 497, coated. Types shall be heavy duty grade D.
 - Step Irons : to BS 1247.
 - Steel Ladders : to BS 4211, mild steel, galvanized to BS 729.
- c. Channels in bottom of manhole are shall be smooth, semi-circular and size equal to diameter of adjacent sewers. For straight through manholes, construct channels of half pipe sections. Make changes in direction of flow with smooth curves as large as manholes permit. Changes in size and grade of channels are shall be gradual and even.
- d. Benching shall be formed in sulphate resisting concrete Class B and to rise vertically from top of channels to a height not less than soffit of outlet pipe, then sloped upwards 1 in 10 to walls. Within 3 hours, shall be floated with coat of sulphate resisting cement-sand mortar 1:2 and finished smooth with steel trowel.
- e. External Coating: cover faces of manholes and chambers with two coats asphaltic composition applied by brush in accordance with manufacturer's instructions.
- f. Internal Coating: cover faces of manholes and chambers with two coats pitch epoxide coating applied by brush in accordance with manufacturer's instructions.
- g. Adjustment for level build top courses of brickwork or blockwork after completion of surrounding levels. Adjust as necessary to give accurate and even final levels.
- h. Covers and Gratings: bed frame solidly in mortar with cover in position to prevent twisting. Position centrally over opening and level and square with surrounding finishes.
- j. Testing of Manholes: plug manhole inlets and outlets, fill manhole with water and allow to stand for at least 24 hours or such longer period to allow for complete absorption. Re-top with water. Allowable leakage over 24 hours is not to exceed 1% of total volume of manhole, otherwise make good and retest.

J. Service Connections to Municipal Networks

- a. Location : agree location and invert level of connections with the Engineer's Representative before starting construction.
- b. Programme connections to follow closely construction of pipeline.
- c. Execution Connection to sewer is shall be at manhole where possible, or by T or Y junction.
- d. Minimum Grade : lay connections at minimum grade of 20 per 1000 unless otherwise approved.
- e. Install, bed and test connections in same manner as main pipelines.
- f. Records : maintain accurate records of location of connection to main sewer. Record details of the following:
 - connection number
 - type of connection
 - diameter
 - downstream manhole number
 - distance from manhole
 - position (left or right) when facing upstream of street sewer
 - distance from centre line of sewer to end lateral
 - invert of street sewer
 - lateral invert at end point
 - number of inspection chambers
 - cover type
 - location, description and elevation of obstructions and method of protection.
- g. Keep records in an approved survey log book, made available for inspection and handed to the Employer on completion. Transfer information to sketches and tables as agreed with the Engineer's Representative, provide three bound copies and hand to the Employer.

SANITARY FIXTURES (15440)**A. Scope**

The scope of the sanitary fixtures and accessories shall be as specified herein and as detailed in the Bills of Quantities.

B. Performance and Standards

The work shall comply with the latest applicable standards and codes and shall be in accordance with the manufacturers recommendations.

C. Related Items

Mortar 04100
Mechanical Division 15

D. Submittals

- a. List of all proposed plumbing fixtures, trim and accessories, indicating manufacturer, type and model number and catalogues shall be submitted for approval.
- b. Samples for fixtures, trim and accessories shall be submitted for approval.

E. Product Handling

The Contractor shall store all products in a clean and workmanable manner under cover in weatherproof sheds and kept dry.

F. Materials**1. General**

- a. Plumbing fixtures, trim and accessories shall be obtained from one approved manufacturer unless otherwise specified.
- b. Vitreous china : first quality, of specified colour, with smooth glazed surfaces free from warps, cracks, checks, flaws, discolouration or other imperfections.
- c. Vitreous china accessories: to match fixtures and of same manufacture and colour.
- d. Exposed piping and metal trim : chrome plated brass with polished finish guaranteed not to strip or peel off.
- e. Black bitumen coating solution for cold application to BS 3416 Type 1.
- f. Waterproof jointing compound for wastes : type recommended by waste manufacturer.

2. Lavatories

- a- White, vitreous china LECICO CLINIC SET for special needs persons toilets.
- b. White, vitreous china, with overflow, Lecico LAGUNA or approved equal, complete with accessories for all other areas.

3. Water Closets

- a- White, vitreous china LECICO CLINIC SET for special needs persons toilets.
- b. White, vitreous china, Lecico- delta S. without reservoirs, suitable for flush valve installation, complete with the accessories (for public toilets) :

- White solid plastic seat and cover with metal hinge, rubber washers and plastic screws and nuts,
- 3/8" angle valve with 300mm long tube,
- Stainless steel toilet paper holder, with hood and plastic roller exposed surface mounted type, polished finish Bobrick B-66997.

c. Idem LAGUNA with reservoir or approved equal (for patients Bedroom).

4. Shower tray

a- Similar to MUREX 80x80 for all areas. with Shower rose and support similar to GROHE RELAX PLUS shower system..

5. Sinks (Refer to architectural specifications, Corean or Resin as specified according to the area of application) except janitor room.

- a. Janitor Sink: Stainless steel similar to IDEAL STANDARD Janitorial sink reference S6509MY, with related mixer.
- b. Kitchen Sink (Refer to the kitchen equipment specifications and bill of quantities)
- c. Scrub-up sink
Stainless steel, single bowl, single drainer, 16 gauge thickness, with splash back, of sizes as shown on drawings, as manufactured by Franke.

6. Liquid soap dispenser
Wall mounted heavy gauge stainless steel with concealed fixing wall plate similar to Bobrick model B2113 or approved equal.

7. Towel Paper Dispenser
Stainless steel, surface mounted with sloping top, refill indicator slots, and a pivot type door hinge, 290 x 375 x 100mm, Bobrick No. 26212 or approved equal.

8. Towel Holder
Similar to BOBRICK B-530x24

9. Towel Hooks
Similar to BOBRICK B-2116

10. Sanitary Mixer

- a. Sanitary mixers, tabs and accessories for all toilets shall be similar to GROHE EUROSMArt or approved equal.
- b. Sanitary mixer for Scrub-up shall be special mixer elbow operated similar to GROHE ERGOMIX 34018000.

PACKAGED ROOF TOP AIR CONDITIONING UNITS (15781)

PART 1 - GENERAL

A. Description of Work

- a. The extent of packaged air conditioning unit work is indicated in the drawings and in schedule and in this section.
- b. The packaged air-conditioning unit shall be either single piece or modular construction, self contained, factory assembled, air to air cooling unit.
- c. Definitions: The unit work is hereby defined to include, but not limited to following:
 - 1. The Contractor shall furnish all labour, materials, equipment, accessories, services and tests necessary to complete and make ready for operation by the employer, the unit installations as shown in the drawing and herein after specified. The installation shall be complete workable system including electric power cables and control wiring work from equipment up to the isolator (isolator covered under DIVISION SIXTEEN-ELECTRICAL).
All electrical work shall conform to the requirements of DIVISION SIXTEEN-ELECTRICAL.
 - 2. All builder's work in connection with the installations of the Unitary Air-conditioners.
- d. Builders Work: The following builder's work shall be allowed for by the Contractor under this section.
 - 1. Necessary concrete pedestal for the packaged unit.
 - 2. Forming, cutting away for and making good all openings, holes, chases mortises etc.
 - 3. Necessary material and equipment for lifting, hoisting etc. to allow installation of unit at the required location.
 - 4. Supplying, during the erection electrical power of necessary characteristic to provide illumination, operation of required tools and hoists and power for starting, testing and adjusting the equipment.
 - 5. Cable duct/conduits etc. for the installation of Elect/Control Wiring and Refrigerant piping.
 - 6. Painting as specified elsewhere.All the above builder's work shall be carried out to the entire satisfaction of the Engineer and in accordance with the unit specification.

B. Quality Assurance

- a. The units shall be designed, constructed and rated in accordance with ARI 210 and 360 standards.
- b. The units shall be stored and handled as per the manufacturer's instructions.

C. Submittals

a. Product Data:

Submit manufacturer's product information on capacity, overall dimension, maintenance space requirements, supply and return air opening sizes, power requirement, weight and supports.

b. Manufacturer's certified cooling capacity for the selected equipment and compliance with the equipment schedule.

c. Shop Drawings:

The layout drawings show the location of the unit on the basis of a certain product catalogue. The contractor should consider the drawings as indicative and shall prepare the drawings on the basis of the catalogue information of the selected equipment. The unit overall dimensions, weight, supply air and return air connection sizes, maintenance space requirement etc. vary from manufacturer to manufacturer and therefore the contractor shall prepare the shop drawings as per the technical data and as per the recommendations of the manufacturer of the selected equipment.

The contractor shall coordinate with other trades and ensure adequate size of housekeeping pad for the units, electrical power supply, configurations and sizes of supply air and return air openings in the slab and all other works as required in order to install the selected equipment. All the coordinated work and its compliance with the selection of equipment should be reflected in the shop drawings.

No work shall be carried out without approval of the shop drawings by the Engineer. Submittals on the product selection and the shop drawings should be together.

d. Operation and Maintenance Manual:

Submit bound manual for the units which should include a comprehensive part list, installation instructions, operation instructions, maintenance instructions and trouble shooting. Incorporate sketches and drawings for illustration.

PART 2 - PRODUCTS

A. General

a. The packaged air-conditioning units shall be self contained air to air heat transfer type, piped, internally wired and fully charged with R-22.

B. Casing

- a. The casing shall be constructed of zinc coated steel conforming to ASTM A527, G-90, painted with baked-on electrostatic polyester dry powder paint to make the whole casing weatherproof suitable for outdoor installation.
- b. Removable panels shall be provided in the casing for access to all working part components and connections where servicing is required.
- c. Casing shall be properly reinforced and braced. Joints shall be air and watertight.

C. Compressors

- a. The compressors shall be hermetic reciprocating/scroll conforming to ARI 520 and provided with all the standard accessories necessary for proper and safe operation.
Compressors shall start unloaded. The compressors shall be equipped with high and low pressure controls, crankcase heaters, oil pumps for positive lubrication at all times, mufflers and internal spring mountings. Hermetic compressors shall not be equipped with oil pressure safety controls as this is impossible with welded construction but the whole system shall be designed to prevent loss of oil or pressure drop by control of liquid refrigerant.
- b. Compressors shall be provided with vibration isolators. Where more than one compressors are used, a time delay relay shall be incorporated to prevent simultaneous start of both compressors and independent refrigerant circuits shall be provided.

D. Evaporator Coil Section**a. Cooling Coil:**

The coil section shall be designed to permit coils to be removed and shall have baffles to prevent air by-pass around coils. Cooling coil sections shall have condensate pans and drain connections of sufficient size to remove coil condensate. The refrigerant metering device shall be a thermostatic expansion valve.

b. Drain Pans:

Drain pans shall be provided under the cooling coil section and shall be adequate to catch all condensate leaving the coil. Drain pans shall have at least one drain connection at the low point in drain pan. The drain pan shall be insulated.

c. Insulation:

Insulation shall be supplied in 25mm thickness and of sufficient density to prevent condensate from forming on the unit casing from air entrance at coils to air outlet of unit. Insulation shall meet the requirements of NFPA 90A and shall be protected against deterioration and delamination from air currents. Condensate drain pans shall be insulated with water-impervious insulation in sufficient thickness to prevent condensate formation on the exterior at ambient conditions.

E. Supply Air Fan(S) Section

- a. Supply air fans shall be of a forward curved blade design and sized to suit system pressure. Fan Motors shall be on an adjustable base and secured by a locking device. Fan drive shall be through adjustable pitch pulleys are selected at approximately the midpoint of the adjustable range. Fan shafts shall be designed to operate at less than 2/3rds of the first critical speed when the unit comes up to rated revolutions per minute. Units shall have sealed, permanently lubricated ball (or sleeve) bearings and shall be statically and dynamically balanced in the fan housing during final assembly. Fan motors shall of the totally enclosed type and shall conform to NEMA MG2. Motor starters shall be magnetic, across the line type with either a general purpose weather resistant enclosure. Motor starters shall conform to NEMA ICS-1.

F. Control Panel

- a. A unit mounted local control panel shall be provided to ensure safe and proper operation of the unit. Additionally the panel shall have necessary contacts in order to achieve the "Control Sequence" indicated in the drawings.
- b. All the controls including motor contactor and safety controls shall be mounted inside the weather tight enclosure and all wiring thereof shall be factory installed.

G. Accessories

- a. Fan Cycle Switch Head Pressure Control:

Provide Fan Cycle Switch Head Pressure Control set for a minimum temperature of 35 Deg.C. (95 Deg.F.) saturated refrigerant condensing temperature or to suit the specified application.

- b. Pump Down Solenoid Valve:

A pump down solenoid valve shall be installed in the liquid line to prevent migration of refrigerant during the 'Off' cycle and to prevent 'Slugging' on start up.

- c. Anti Icing Thermostat:

Shall be provided.

- d. Time Delay Relay (TDR):

A five minute TDR shall be installed to provide a predetermined delay so that the compressors do not start simultaneously. A sequencer shall be provided to prevent compressor start-up more than 12 times per hour.

- e. Adjustable High/Low Pressure Switch:

The standard High Pressure Switch and Low Pressure switch shall be set to open at 29.3 kg. per sq.cm. (425 psi) and at 1 .72 kg. per sq.cm. (25 psi) respectively.

An adjustable dual pressure switch shall be provided and the settings shall be field adjusted to suit application.

PART 3 - INSTALLATION

- A. Provide cooling to existing cubicals as per site conditions. This work shall include ducting distribution, air outlets installation and all necessary accessories.
- B. Connect the packaged unit to the nearest panel board. This work shall include wiring, and all necessary accessories.

AIR HANDLING (15850)**A. Ductwork**

Supply and install all ductwork as shown on the drawings and specified herein.

Ducts shall be constructed of galvanized steel sheets conforming to ASTM A 526-71, galvanized by the hot-dip process coating designation G90 or approved equivalent standard. Minimum weight of zinc coating (total on both sides) 275 g/m².

Ductwork shall be installed in accordance with ASHRAE or SMACNA requirements for low pressure ducts.

Ductwork sheets thicknesses shall conform with the following table:

Duct	Largest inches	Dimension (cms)	US Gauge	or	mm
Up	to 12"	(Up to 30)	26		0.60
13"	to 30"	(31 to 75)	24		0.70
31"	to 42"	(76 to 105)	22		0.90
43"	to 54"	(106 to 135)	22		0.90
55"	to 84"	(136 to 210)	20		1.00
85"	to 120"	(211 to 300)	18		1.30

Ducts used for kitchen exhaust shall be black steel 3mm thick.

Ductwork shall be installed complete with:

- Metallic supports, seams, joints, bracings and fixing accessories.
- Flexible canvas connections between ducts and air handling equipment (fans, air handlers, fan coil units, etc...).
- Elbows, splitters, vanes and access doors as per ASHRAE or SMACNA requirements.
- Connections and fixings to air outlets.
- Wood frames for air outlets fixings and ducts passages through walls and slabs.
- Insulation and/or vapour barrier wherever specified.
- Acoustic lining wherever specified and/or indicated on the drawings.

Flat ducts over 18" wide shall be stiffened by cross breaking; however, if duct is made one gauge thicker than required for its size, cross breaking may be omitted.

Horizontal ducts shall be supported from ceilings by means of trapeze type hangers consisting of a 5cms x 5cms x 5mm thick angle iron 10cms longer than the duct width on either side. The angle shall be hung from the ceiling by means of two 10mm round steel rod hangers with threaded ends bolted through the angle with nuts and washers. The rods shall be attached to the ceiling by means of 20mm masonry expansion bolts. Horizontal exposed ducts shall be neatly supported with a round supporting galvanized iron flat bands and round galvanized steel rod hangers.

Vertical ducts shall be supported from the floor or side by means of 5cms x 5cms x 5mm thick angle iron riveted to the ducts and extended to rest on the floor or on similar angles cast in the wall.

Supports shall not be attached to ducts by means of sheet metal screws.

Maximum spacing of duct supports for horizontal ducts shall be as follows:

Duct Largest Dimensions (inches)	Maximum Spacing of Duct Supports
up to 30"	2.4 m

31" to 54"	1.8 m
> 54"	1.2 m

Vertical ducts shall be supported at every storey height.

All parts outside and inside ducts which are visible to the outside through air outlets shall be painted with a matt black colour paint.

All exposed ducts and their supports shall be painted with one coat of primer suitable for galvanized steel and two coats of finishing paint of type and colour as approved by the Engineer.

B. Plenums and Boxes

Supply and install all plenums and duct boxes wherever shown on the drawings and as specified herein.

Unless specifically mentioned otherwise on the drawings, plenums and boxes construction and installation shall be similar to ductwork.

C. Flexible Canvas Connections

Supply and install all flexible canvas connections wherever shown on the drawings and as specified herein.

- Flexible canvas connections shall be flame proof material, fabricated from chemically impregnated canvas.
- Connections to air handling equipment (fans, air handlers, fan coil units, etc,... shall be by means of special bands or clamps which can ensure adequate air tightness.
- The free section of the flexible connections shall be not less than 15cms and not more than 30cms.

Supply and install all air outlets wherever shown on the drawings or specified with the various air handling equipment.

Unless specifically mentioned otherwise, each air outlet shall be constructed of extruded anodized aluminum and painted to the colour as approved by the Engineer.

1. Grilles and Louvers

Each grille shall be complete with:

- Double deflection blades for supply and return grilles and fixed blades for exhaust grilles , transfer grilles and louvers.
- Fixing frame for outlet mounting on walls, doors, ducts, false ceiling, etc... Frame may be of wood or metallic construction as site conditions dictate.
- All necessary supports and fixing accessories for concealed fixing.
- The grilles and louvres shall be power coated.

Louvers Specifications shall be identical to the grilles except that they shall have fixed inclined blades of storm proof construction. Each louver shall be provided with a non corrodible insect screen mesh.

Fixing shall be of the concealed type without screws.

2. Fan Coil Unit Supply and Return Grilles

Fan coil unit supply grilles: double deflection type with individually adjustable horizontal face bars and vertical rear bars.

Fan coil unit return grilles installed on same wall as unit supply grille shall be same size and shape as supply grille.

Fan coil unit return grilles installed in false ceilings shall be fixed blade type with blades set at 45° deflection parallel to long dimension. Grille net free area shall be not less than 70% of gross face area.

Fixing shall be of concealed type with no screws.

3. Door Grilles

Each door grille shall be square or rectangle shape and complete with:

- Inverted "V" or "Y" fixed type horizontal blades.
- Fixing frame for outlet mounting on doors on both sides. Frame may be of wood or metallic construction as site conditions dictate.
- All necessary supports and fixing accessories.

Door grilles shall be installed with bottom at a uniform height of 40 cms above floor level.

E. Fire Dampers

Supply and install fire dampers on all ducts crossing the structural slabs, as shown on drawings and as specified herein.

Fire dampers shall be provided in ducts, walls, or floors, where shown on the drawings, and of detail as shown thereon.

Fire dampers shall be constructed of 3mm thick black steel plate, with frames and blade so designed as to cause no obstruction to air flow when in the open position. Fire dampers shall be rated at 2 hour fire resistance. Fire dampers shall be installed without strain or distortion to any part and all moving parts shall move freely without building. Dampers shall be caulked tight around the frames which shall extend the full thickness of wall or floor in which they are installed.

Fire dampers shall be weighted so that they will close promptly when released regardless of pressure and direction of air flow. The damper blade shall be hung on zinc-coated steel hinges with loose fitting brass pins and bushings. It shall close tightly against angle stops and shall have retaining springs.

The damper blade shall be held open by a fusible link having a melting temperature of not higher than 75° C (167° F). An access door shall be provided in the duct for replacement of the fusible link.

F. Sound Attenuators

Supply and install sound attenuators on all air handling equipment to satisfy the required noise level criteria whether or not shown on drawings and as specified.

a. Sound attenuators shall be suitable for 100 mm W.G. internal air pressure and 40 deg. C operating air temperature. Maximum static pressure drop through silencer is not to exceed 5 mm W.G. at specified air quantity. Silencer to attenuate sound by at least 10 DB in the 125 Hz and 30 DB in the 2000 Hz octave band mid-frequencies respectively.

b. Sound attenuators for axial flow fans: shall be the product of fan manufacturer, designed to match fan with end rings drilled and tapped to match fan flanges. Silencer shall be cylindrical type with centre pod, comprising galvanized steel casing lined with mineral wool and retained by expanded steel. Lining shall be rot proof and fire proof faced to withstand high air velocities without erosion.

Sound attenuators shall have specially designed sound absorbent single or double pods mounted concentrically within lined outer casing. It is shall be complete with lifting lugs and mounting feet of same type supplied for fan.

- c. Sound attenuators for air handling units: straight, rectangular, splitter type, designed for mounting in ducts, with pre-drilled flanges. Silencer shall have number of air passages in parallel and in height and width to meet resistance to air flow requirements and length to meet sound attenuation requirements.

Sound attenuators to comprise multiple galvanized steel splitters held in galvanized steel casing. Splitters and casing shall be lined with rot-proof and fire-proof resin bonded mineral wool faced with woven glass fibre.

G. Centrifugal Fans

Supply and install all centrifugal fans wherever shown on the drawings and as specified herein.

Fans shall be V-belt driven, suitable for floor mounting and shall be complete with:

- a. Heavy structural steel housing, wheel, drive and supports. Single width, single inlet or double width, double inlet as shown on drawings.
- b. Silent type, centrifugal wheel statically and dynamically balanced, backward inclined blades.
- c. Totally enclosed fan cooled electric motor designed for a maximum speed of 1450 rpm, with built-in motor overload protection.
- d. Adjustable base for electric drive motor.
- e. Heavy duty bearings, grease lubricated, self aligning, pillow block, ball or roller type, on both sides of the fan wheel.
- f. Duct connecting flanges and gaskets.
- g. Flexible canvas connections connecting fan with associated ductwork.
- h. Vibration isolation structural steel base with spring isolators and supports.
- j. Adjustable V-belt drive with belts and guard.
- k. Additional features and accessories required for its installation and satisfactory operation.

Capacity and type of each centrifugal fan shall be as given in the schedules of capacities and/or the Bills of Quantities.

H. Axial Fans

Supply and install all axial fans wherever shown on the drawings and as specified herein.

Axial fans shall be suitable either for panel or frame mounting or for duct mounting as conditions may require.

Each axial fan shall be complete with:

- a. Silent propeller blades statically and dynamically balanced.
- b. Totally enclosed, fan cooled motor with built-in overload protection and a maximum speed of 950 rpm.
- c. Heavy gauge steel housing, mounting flanges and gaskets.
- d. Motor starter and isolating switch.
- e. Flexible canvas connections connecting fan with associated ductwork whenever provided.
- f. Additional features and accessories required for its installation and satisfactory operation.

Capacity and type of each axial fan shall be as given in the schedules of capacities and/or the Bills of Quantities.

J. Propeller Fans

Supply and install propeller fans as specified herein:

- a. Wall mounting type, supplied complete with electric motor, pressed steel ring mounting plate, wire guard on motor side, discharge louver shutters with aluminum frame.
- b. Steel blades, statically and dynamically balanced .
- c. Heavy duty ball bearing, prelubricated with high quality lithium base grease.

L. Fan Coil Units

Supply and install fan coil unit wherever shown on the drawings and as specified herein.

Basic unit to consist of water coil, one or more centrifugal fans, electric motor, condensate drain pan, galvanized steel casing panels, filter, electric junction box and fan switch. Unit shall be suitable for both chilled and hot water.

Water coil: staggered 12.7mm O.D. heavy wall seamless copper tubes mechanically bonded to aluminum fins, with 15mm solder joint copper tube connections and manual air vent. Coil shall be leak tested at factory to 24 bars (350 psi) minimum air pressure under water.

Basic unit casing: 18 gauge galvanized steel sheet braced and reinforced for maximum rigidity, thermally and acoustically insulated with fiberglass blankets fastened with waterproof adhesive.

Centrifugal fans: forward curved, non-overloading type, directly connected to fan motor, statically and dynamically balanced and designed for whisper quiet operation. Materials shall be high strength and corrosion resistant.

Motor: split capacitor, 3-speed type, with built-in thermal overload protection and bronze sleeve type bearings with oil reservoirs. Motor shall be resiliently mounted.

Condensate drain pan: 18 gauge galvanized steel extended type specially constructed, projecting under entire length and width of coil including headers and return bends, valves and fittings. Pan shall be treated against corrosion, insulated and pitched for positive drainage with unit installed level.

Fan switch: 3-speed with 'OFF', provided with each unit from factory. Decorative wall plate remote type for horizontal units. Unit mounted and prewired type for vertical units.

Horizontal concealed unit: basic unit complete with four rubber grommets for ceiling mounting and isolation and with return filter plenum consisting of mixing box forming integral part of unit, bottom access and 25mm thick cleanable aluminum filter.

Vertical concealed unit: basic unit complete with sub-base for floor mounting with levelling adjustment, secondary condensate pan, permanent, cleanable, aluminum air filters with provision in unit casing for easy removal of filters.

Vertical cabinet unit: basic unit complete with decorative cabinet constructed from cold rolled, heavy gauge sheet steel, bonderized, coated with baked enamel finish and thermally and acoustically insulated. Cabinet shall have stamped discharge grille on top, return air opening on bottom an two access doors on either side for easy manipulation of controls and air vent. Unit shall have removable single piece front panel to give complete access to internal components.

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M. Air handling units

Supply and install air handling unit wherever shown on the drawings and as specified herein.

M1 General

- Each unit consist of fan, motor, V-belt drive, cooling and/or heating coils as required, drain pan, filters and necessary controls.
- The unit shall be either mounted on a suitable base, or hung from the ceiling. In all cases approved vibration eliminators shall be provided. The Contractor shall submit details of bases, mountings and connections to the Engineer for approval.
- The unit(s) shall be of the draw thru Low/medium pressure type.
- The contractor shall confirm to the Engineer the total static pressure of the fan after the Engineer's approval on the air handle and after preparing the shop drawings.

M2 Construction

- Air handling unit shall be constructed of a heavy gauge galvanised steel with removable panels for accessibility to all internal parts.
- Unit(s) shall be factory insulated internally with fiberglass 40mm, thick or approved equivalent and finished with oven dried grey finishing coat.

M3 Fan section

- The fan section shall be constructed of heavy gauge sheet steel properly reinforced and braced with steel angle framework. It shall be provided with suitable angle flanges for connecting it to the coil section.
- Fan shall be centrifugal type with multi-blade forward curved or air foil type, mounted on a common shaft with enclosed housing. The fan motor shall be statically and dynamically balanced to eliminate noise and vibration.
- Fans bearings shall be grease lubricated ball type with grease lines extending to the outside surface of the casing. Average life of bearing shall not be less than 200000 hours.
- Fan shall conform to the design fabrication of the AMCA.
- Fan shall be mastic coated and have galvanised steel wheel and high grade steel shaft.
- Fan shall be driven by V-belt of variable pitch type. Belt guards of removable type shall be provided on the fan and motor shafts.
- The electric motor starter and controllers shall be in accordance with the Electrical section of these specifications.

M4 Coils

- The coil shall be suitable for chilled and/or hot water application.
- The coil shall be of seamless copper tubing, having aluminum fins mechanically bonded to the tubes.

- The headers shall be of seamless copper with supply and return connections. Each header shall be provided with drains and vents.
- The coil shall be tested at not less than 250psig (1725 Kpa).
- The face velocity shall not exceed 550 FPM (2.8m/s).
- The coil shall be accessible for service and shall be removable without dismantling the entire unit.

M5 Filter section

- The air filter section shall consist of prefilter and final filter stages. Pressure drop in the filter when dirty shall not exceed $\frac{1}{2}$ " WG (125 pa). Filters shall be easily removable for cleaning.
- Filters shall be provided with rigid self supporting corrosion resistant steel frames and clamps, gasketed and sealed to prevent air bypass.

M6 Drain pan

- An insulated drain pan shall be provided in each unit under both the fan and the coil section.
- Drains pans shall have drain connections on both sides and a deep seal trap.
- Drain pan shall be suitably connected to the drainage system.

N. Air handling units for operating theaters

N1 General

The Contractor shall supply and install central station air handling units, double skin, draw-through, vertical or horizontal type as indicated, complete with fan, electric motor, V-belt driver, cooling coil, heating coil, air filters, necessary control and accessories as shown on the drawings. Capacities are as indicated on the drawings.

N2 Construction

Shall be double skinned, sectionalized, comprising fan section, coil section and specified accessories as specifically designed by manufacturer for unit. Fan and coil section casings and accessory casings shall be heavy gauge, mill galvanised formed steel panels adequately braced and reinforced for maximum rigidity. Casing panels to removable for easy access to internal components.

N3 Casing

Factory fabricated acoustic panel casings, double skin 0.5mm thick galvanised outer and inner sheets, a "Penta Post" supporting frame. Panels and frames are shall be secured using internally bolted fixings so that welding minimized and integrity of the galvanised finish is maintained. Panels are shall be provided with 25mm thick fiberglass filter and shall be designed to withstand an internal positive pressure of 250mm water gauge in the outlet section and an internal negative pressure of 75mm water gauge in the fan inlet section.

Casing shall be fitted with quick release doors. All panels are shall be screwed on external side to permit removal of components through either side of unit. Casing shall be self supporting on 3mm horizontal span or 3.6mm vertical span.

N4 Coating

Casing panels are shall be pre-coated externally and internally with 10 microns of primer and 200 microns of plastisol topcsart.

N5 Insulation

All sections shall be thermally and acoustically insulated with 25mm thick, 41kg/m³ density, neoprene coated fiberglass insulation secured to internal surface of casing panels with waterproof adhesive and permanent fasteners.

N6 Fan section

Shall have one or more centrifugal fans, with BI blades, mounted and keyed on common heat-treated, ground and polished solid steel shaft. Shaft shall be supported on self aligning pillow block regreasable ball bearings. Fan wheels and scrolls to bonderized steel painted with baked enamel or unpainted mill galvanised steel.

N7 Inlet guide vanes

Shall be provided where indicated in the schedule of equipment, in both inlets of fan and shall be installed within the inlet bells. Vane operating shafts shall be connected to control ring by crankarms. Both sets of vanes shall be operated by a lever on the fan scroll with connecting shaft between inlets. Operating of inlet vanes shall be means of a pressure controller.

N8 Motor

Totally enclosed, squirrel cage, introduction type, mounted on adjustable bracket securely supported on internal framing of fan section with minimum class F insulation. Once a motor fails to start an alarm signal is shall be activated at the operator console.

N9 Drive

To comprise fan pulley, adjustable motor sheave, V-belt, belt guard and provision for belt tensioning adjustement.

N10 Coil section

Shall have heavy duty coil tracks extending full width to support coils throughout their length and to provide easy removal of coils from coil connections side of casing. Condensate drain pan of double wall construction is to extend under whole coil section, fixed to it and adequately pitched to amply sized threaded drain connections on both sides. Pan shall be treated against corrosion and adequately insulated and vapour sealed between outer and inner walls. Stacked cooling coils shall have intermediate drain pans with drop tubes at either end to drain into main drain pan.

N11 Coil construction

Shall be removable cartridge type constructed of heavy wall seamless copper tubes bonded to aluminum fins by mechanical expansion and staggered in direction of air flow. Coil shall be leak tested at factory to 2410 Kpa minimum air pressure with coil submerged in water. Coil face area is not to exceed 2.5 meters per second coil face velocity at specified air quantity. Coil shall have number of rows and fins per cm to satisfy required capacity at specified condition, with not more than 5 fins per cm.

N12 Chilled water and hot water coil

Shall have galvanised steel casing and steel headers treated against corrosion. Coil shall be mounted in coil section shall be free draining and continuously vented with non-air trapping circuits. Headers and U-bends shall be within casing. Coil shall have vent and drain fittings on each header. Number of circuits shall be such that water velocity satisfies specified conditions without exceeding specified maximum water pressure drop through coil. Water velocity through tubes is not to exceed 1.8 meters per second and not less than 0.76 meter per second.

N13 High velocity filter section

Shall be bolted to coil section inlet, complete with access doors for easy removal of filters from either side and with required number of high velocity, 50mm thick, permanent, cleanable, aluminum air filters.

N14 Bag filter section

Shall be standard double skinned, bag section provided with stiffener bars for rigidity, with double skinned, down stream access door, provided with compartment lifting. Bag filter media 550m thick, fire resistant finer, fibred all glass medium 80-90% dusty spot efficiency to ASHRAE 52-76, combined to corrosion resistant framing, section shall be provided with hanging clips bulkhead light and glass inspection panel.

N15 Dampers Leakage Rate

Do not exceed the following for a pressure differential between the up-stream part and down-stream part of damper of 100 pa when damper is closed.

Number of modules :

Leak (m ³ /hr)	1	2	3	4	5	6	7	8
	130	260	390	520	650	780	910	1040

N16 Accessories

Access doors shall be double skinned, gasketed air tight to ASTM 1056-79 and provided with heavy hinges and quick release catches. All service and inspection doors shall be mounted flush, sheathed to match the unit siding. Doors to open against the air pressure.

N17 Vibration isolators

Shall be provided on all air handling units and shall be spring type, free standing and laterally stable without any housing and complete with 6mm neoprene acoustical friction pads between the base plate, and the support. All mountings shall have leveling bolts that must be rigidly bolted to the equipment. Spring diameters shall be not less than 0.8 of the compressed height of the spring at rated load. Springs shall have minimum additional travel to solid equal to 50% of the rated deflection.

N18 Controls**1. General**

Operation rooms' HVAC control system shall be made up to the highest standards so that it will provide proper and completely separate control of the space temperature and humidity conditions of each operating room up to the

surgeon set conditions. The Contractor shall provide all sensors and control devices required for proper operation and to the satisfaction of the Engineer.

2. Control general description

A central controller of the DDC type (direct digital controller) shall be provided at the air handling units room to control the primary circuit (air handling unit) and the secondary circuits at each operating room (hot water coilsheater & electric humidifier),

DDC shall be equipped with a fixed operator terminal to control and monitor the various HVAC conditions of the operating room as herein below described.

3. Control sequence

a. Primary circuit (AHU)

Temperature and humidity sensor located in the supply air duct shall sense the supply air temperature and humidity level and shall send a signal to the direct digital controller (DDC) which will compare it with the temperature and humidity level set points and it will control the cooling coil 3 way motorized valve and the heating coil 3 way motorized valve to achieve the required air conditions.

In case the supply air (SA) humidity level is greater than the preset conditions, the DDC will set the AHU for dehumidification mode and it will overcool and reheat the air so that the SA temperature and humidity reaches the preset level.

Differential pressure switches shall be provided for every filter bank stage, which will relay the DDC whenever the pressure drop in the filter bank reaches the preset level. The DDC will actuate an audible and visual alarm to indicate dirty filter condition.

Smoke detector installed in the supply air duct (SAD) shall detect smoke in the duct and shall relay the DDC to de-energise the air hanlder fan and initiate audible and visual alarm, also it will send a signal to the main fire alarm control panel (if available).

b. Secondary circuit

Individual temperature and humidity remote set points shall be provided at each operating room to set the required operating room temperature and humidity levels. The set points shall be connected to the DDC which will control the secondary circuit elements.

Temperature and humidity sensors located in the room exhaust air duct branch shall sense the temperature and humidity level and shall relay the DDC to control the current valve of the duct heater (if heating the air is required), and to control the humidifier (if humidification is required) to meet the individual room set points.

A flow switch is provided at the secondary circuit to sense the air flow, which will be connected to the DDC, the DDC shall forbid the energization of the secondary electric heater in case of zero flow.

Smoke detector is provided and connected to the DDC to stop the primary supply air fan in case of smoke detection and to initiate an audible and visual alarm at the main panel and at the surgeon panel.

A differential switch is provided for the room absolute filter and connected to the DDC to indicate dirty filter, (whenever it reaches the preset level), on the main panel and on the surgeon panel.

The DDC shall measure the room temperature and humidity and shall indicate the conditions at the surgeon panel.

The surgeon panel of every operating room shall house the following:

- Temperature setting point
- Humidity level setting point
- Room temperature digital indicator
- Room humidity level digital indicator
- Room filter (clean/dirty) indicator
- Room pressure (+ve/-ve) indication (described under room pressurization below).

c. Operating room pressurization

A pressure transmitter shall be provided in each of the dirty and clean corridors of the operating rooms.

Also one pressure transmitter shall be provided for every operating room.

The DDC shall compare the pressure levels in each of the operating rooms and the adjacent clean and dirty rooms and shall indicate (+ve) or (-ve) pressure of each room at the main panel and at each relevant surgeon panel. If (-ve) pressure is detected, audible alarm must be initiated in addition to the visual indication.

4. Digital controller

a. Hardware

Digital plant Control processors (PCPs) shall be 16 bit microprocessor types with EPROM OS and EEPROM or flash memory for all data file and control programs. PCPs shall have internal real -time clocks with a minimum of 72 hours battery backup power up to 30 days capacity.

PCPs shall be provided where shown or specified with capacity to accommodate input/output (I/O) points required for the application plus spare points specified.

These panels shall be configured with analog and digital inputs and outputs, and pulse counting totalizers and such that the input , the output and all control logic shall be resident in a single microprocessor to provide stand-alone closed loop DDC. Each panel shall have as a minimum 12 universal (field selectable as analog or digital) inputs and 12 universal outputs. Analog configurated outputs shall be true variable voltage (0-10v) for driving analog devices. Analog outputs shall have a minimum incremental resolution of one percent of the operating range of the controlled device. Each panel shall be provided with a socket for a Portable Operators Terminal (POT), or note book PC.

PCPs shall have LEDs for continuos indication of power and operational status. PCPs shall also have LEDs to indicate the status of each digital input and each output (analog output LEDs shall be variable intensity). Each output shall have an associated on-off auto or open-closed-auto switch. All LEDs and swiches shall be visible without opening the panel door, but not accessible without opening the panel door.

All panel electronics shall be installed in suitable enclosures. Equipment room panels shall have hinged doors and shall also contain all load relays, transducers, and associated equipment.

b. Control software

Each PCP shall contain up to 20 unique user modifiable time programs (TP).

Each TP shall consist of daily, weekly, and annual programs plus a "Today" temporary function.

Daily programs shall be definable for day types such as working day, half day, holiday, weekend, etc. Each daily program shall allow a list of time based (or optimum time based) analog and digital commands shall be issued to user selected plant elements and points.

Weekly programs shall allow a user selected set of daily programs shall be defined for each of the week (Monday through Sunday)

The annual program shall initially be an automatic compilation of 52 weekly programs. Selecting a date of the annual program shall allow modification of the daily selection entered into the weekly program (such as changing Dec. 25 from a working day to holiday).

Control application Software shall be customized strictly to meet the detailed requirements of the "Seqency of Operation" specified hereinafter. PCPs shall be fully programmable. Initial software shall be fully modifiable, and not restricted by vendor's specific configuration guidelines. All PCP control software shall be designed via graphic programming facility, the detailed graphic design of which shall be provided as system documentation. All control strategies shall be advanced as noted with stabilizing setpoint ramps and procedures to assure slow loading of variable load equipment.

c. Management Software

1. Each PCP shall be provided with a trend archive of least the last 200 events (digital transitions or analog value changes) of any user selected group of up to 20 points. A stored event shall include date and time, and value or status. Events occurring in excess of 200 shall overwrite the oldest events, except where a modern module is specified, events shall be uploaded to the modern module. Pointy events shall be displayable on the POT as trend logs for evaluation of control system performance.

2. Each PCP shall monitor all analog input points and specified digital points for off-normal conditions. Each alarm shall have an "alarm delay" attribute which shall determine how long (in minutes/seconds) a point must be in an off-normal state prior shall being considered in an alarm state. Alarms shall be displayable on the POT.

d. Operator's Terminal Panel

1. General

A fixed liquid crystal display and entry key board, (or note book PC), shall be provided for operator readout of systems variables, override control, and adjustment of control parameters at all PCPs and for all TECs shall display points with English - language descriptions.

The terminal panel shall be complete with command keys, data entry keys, cursor control keys, and a liquid crystal alpha- numeric display. Access is shall be via self - prompting menu selection with next menu/previous menu and step forward/step backward within a given menu.

Displays shall provide text via a 64 - character minimum screen with unique English descriptors for each specified physical and pseudo point.

2. Terminal Functionality

Terminal functionality shall include :

a. Display for :

- Space temperature
- Local set point value (Degrees °F)
- Mode : Occupied/Unoccupied
- Mode : Heating/Cooling
- Actual CFM primary air
- Fan status
- Heating status
- Zone override status
- Room pressurization level
- Filter condition
- All other required as described before.

b. Display and command for :

- Dry bulb and relative humidity
- Setpoint select (local/remote)
- Allowable local setpoint mid-range
- Allowable local setpoint range
- Unoccupied setpoint - cooling humidity level
- Unoccupied setpoint - heating
- Deadband for heating
- Proportional band heating
- Proportional band cooling
- Proportional band humidification
- Integral gain cooling
- Integral gain heating
- Derivative gain heating
- Derivative gain cooling
- all other required as described before.

3. Terminal panel minimum Functionality shall be as follows :

- a. Terminal panel shall allow the user to display software information, and via password control, modify PCP software. Two levels of user controlled passwords shall be provided. The first level shall allow the user to modify, create, or delete time programs, and the second level shall allow the user to modify data point text descriptors, reset totalizers, modify setpoints and parameters, set the system clock, and view trend logs alarms.
- b. Selecting Data Points from the top level menu shall initiate an interactive process to select any point via English menu, select manual or analog commanding of the point, select a display of equipment accumulated runtimes, select a historical trend log display of any trended point, or display all points whose alarm capability has been suppressed and allow the suppression shall be canceled.
- c. Selecting Parameters from the top level menu shall initiate a scrolling of all PCP parameters (such as alarm units, control settings, etc.) which may be displayed and commanded.

- d. Selecting Alarms from the top level menu shall present a menu of four alarm display options. selecting Alarm Memory shall scroll a list of all alarms in memory with English descriptor, alarm value or status, alarm type (low alarm limit, etc.), and time of occurrence. Selecting Points in Alarm will produce a similar display of all points currently in alarm. selecting Critical Alarms shall display critical points currently in alarm. selecting Non-Critical alarms shall display non-critical points still in alarm.
- e. Selecting Trend LOG from the top level menu shall initiate a scroll selection bar of English descriptors of all points being trended, and allow selection of trend values/events with date and time of each historical occurrence.
- f. Selecting System Clock from the top level menu shall allow the user to modify the calendar/time clock and enter a date for automatic change to/from daylight savings time.

O. HEPA Filter

Supply and install HEPA filter in line of fresh air duct related to operating rooms as shown on the drawings and as specified herein :

- Efficiency MPPS 99,95 % - EN 1822:2009 classification H13- Final pressure drop 600 Pascals
- Maximum operating temperature 70 °C
- Maximum relative humidity 100 % CE mark ATEX version
- Nominal air flow rate ;as shown on drawings and bill of quantities
- type absolute filters of the highest filtering surface.
- Frontal air speed : 2.5 - 3 m/s
- Galvanized steel frame Filter to have a special expanded polyurethane single piece gasket.
- Modulo housings can be used for duct or wall filtration systems.
- Shall have a very flexible systems easy to install, made of galvanized steel sheet and have an access door with handle and wheel fitting, fitted with a closed cell neoprene gasket on door ledge. The filter is locked using an eccentric lever. Perforated flanges with M8 threaded inserts are positioned at air inlet/outlet.

R. Energy Recovery Fresh Air Handling Units

R1 General

Energy Recovery Ventilator shall be listed per ANSI/UL 1995, Heating and Cooling Equipment. Energy transfer ratings of the energy recovery wheel shall be ARI Certified. Performance shall be as scheduled on plans. Exhaust discharge and outside air intake shall not be located on the same side on roof top units.

R2 Unit Casing and Frames

Unit shall be of internal frame type construction of galvanized steel. Frame and panels shall be G90 galvanized steel. All panels exposed to the weather shall be a minimum of 18 gauge galvanized steel. Unit shall be internally lined with galvanized sheet metal creating a double wall. Where top panels are joined there shall be an overlapping, standing seam to insure positive weather protection. All metal-to-metal seams shall be factory sealed, requiring no caulking at job site. Permatector exterior finish is available for outdoor units.

Unit base to be designed for curb mounting. Unit base shall overhang the curb for a positive seal against water run-off.

R3 Weatherhoods

Weatherhoods shall be the same finish as the unit. Outdoor air weatherhood shall incorporate a louvered design and moisture eliminator. Weatherhoods shall be tested in accordance with AMCA Standard 500-L and achieve an 'A' water penetration classification rating up to 8 in/hr rainfall at 50 mph.

R4 Insulation

Unit casing to be insulated with 2-inch fiberglass. Insulation shall meet requirements of NFPA 90A and tested to meet UL 181 erosion requirements. Insulation to be enclosed in double wall construction.

R5 Energy Recovery Wheels

Wheels shall be of the enthalpy type for both sensible and latent heat recovery and be designed to insure laminar flow. Energy transfer ratings must be ARI Certified to Standard 1060 and bear the ARI certification symbol for ARI Air-to-Air Energy Recovery Ventilation Equipment Certification Program based on ARI 1060. Ratings "in accordance with 1060" without certification are not acceptable. Desiccant shall be silica gel for maximum latent energy transfer. Wheel shall be constructed of lightweight polymer media to minimize shaft and bearing loads. Polymer media shall be mounted in a stainless steel rotor for corrosion resistance.

Wheel design shall consist of removable segments for ease of service and/or cleaning. Silica gel desiccant shall be permanently bonded to wheel media to retain latent heat capability after cleaning. Wheels with sprayed on desiccant coatings are not acceptable. Wheels with desiccant applied after wheel formation are not acceptable. Energy recovery device shall transfer moisture entirely in the vapor phase.

Energy recovery drive belt material shall be high strength urethane and shall be factory installed in a pre-stretched state, eliminating the need for field belt tension adjustment. Link style belts are not acceptable.

R6 Access Doors

All components shall be easily accessible through removable doors for exhaust, supply, filter, and damper compartments. Energy recovery wheels shall have ample access for ease of inspection, removal, and cleaning.

R7 Roof Curbs

Roof curb to be supplied by unit manufacturer for field assembly. Curb shall consist of die formed galvanized steel sections. Curb shall be full perimeter type with gasketing provided for field installation between curb and unit base.

R8 Fan Sections

Plenum supply fan to be non-overloading, airfoil style, centrifugal type. Bearing supports shall be constructed of welded structural steel members to prevent vibration and to rigidly support the fan shaft and bearings. The fan wheel shall be of the non-overloading centrifugal type. Wheels shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19. The wheel cone and fan inlet cone shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency. Turned, precision ground and polished steel shafts shall be sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class. Close tolerances shall be maintained where the shaft makes contact with the bearing. Bearings shall be heavy duty, grease lubricated, self-aligning ball or roller pillow block type. Bearings shall be selected for a minimum life (L-10) of 80,000 hours at maximum operating speed and horsepower for each construction level. Each assembled fan shall be test run at the factory at the specified fan RPM and vibration signatures shall be taken on each bearing in the horizontal, vertical, and axial direction. The maximum allowable fan vibration shall be 0.150 in/sec peak velocity, filter-in reading as measured at the fan RPM. Fans shall be licensed to bear the AMCA Seal for sound and air performance.

Centrifugal exhaust fans to be double width, double inlet, forward curved type. Blower wheels shall be statically and dynamically balanced. Ground and polished steel fan shafts shall be mounted in permanently lubricated, sealed ball bearing pillow blocks. Bearings shall be selected for a minimum (L10) life in excess of 100,000 hours at maximum cataloged operating speeds. Separate motors for exhaust and supply blowers shall be provided. Adjustable sheaves on belt-driven fans with motors less than 10 hp shall allow independent balancing of exhaust and supply airflows. Fan and motor assemblies are mounted to unit base with neoprene isolators as standard. Fans shall be located in draw-through position in reference to the energy recovery wheel.

R9 Motors and Drives

Motors shall be energy efficient, complying with EPACT standards, for single speed ODP and TE enclosures. Motors shall be permanently lubricated, heavy-duty type, matched to the fan load and furnished at the specified voltage, phase, and enclosure. Drives shall be sized for a minimum of 150% of driven horsepower. Pulleys shall be of the fully machined cast type, keyed and securely attached to the fan wheel and motor shafts; 10 horsepower and less shall be supplied with an adjustable drive pulley. Energy wheel motors shall have integral overload protection.

R10 Filters

Supply and exhaust air filters shall be 2-inch thick pleated fiberglass, 30% efficient and tested to meet UL Class 2. Filter racks shall be die-formed galvanized steel.

R11 Electrical

All internal electrical components shall be factory wired for single point power connection. Units with electric reheat will be wired with independent power supply. All electrical components shall be UL Listed, Approved, or Classified where applicable and wired in compliance with the National Electrical Code.

Weatherproof, integral door interlocking disconnect switch, motor starters, control circuit fusing, control transformer for 24 VAC circuit, and terminal strip shall be supplied as standard components in the control center. Motor starters consist of a contactor and Class 20 electronic adjustable overload protection and shall be provided for all motors in the unit.

R12 Cooling Coil

Direct expansion (DX) and chilled water coils shall be factory tested and rated in accordance with ARI 410. Coils shall have copper tubes with permanently expanded aluminum fins, 12 fpi or less. DX coils shall be equipped with distributors to receive expansion valves at the liquid connections.

R13 Warranty

The energy recovery ventilator shall be warranted to be free from defects in material and workmanship for a period of one year from the purchase date. The energy recovery wheels shall be warranted to be free from defects in material and workmanship for a period of five years from the purchase date. Motors shall be warranted by the motor manufacturer for a period of one year

S. Vacuum and Compressed Room Acoustical Insulation System

Supply and install vacuum and compressed room acoustical insulation system wherever shown on the drawings and as specified herein :

The vacuum and compressed air room shall be acoustically insulated to respect acceptable sound levels specified 15005 - J1, in all adjacent spaces.

- Room access door shall be acoustical
- All room walls shall be acoustical.

CONTROLS AND INSTRUMENTS (15950)

A. General Requirements

Controls and instruments are mentioned and specified under each system or equipment shall be provided in this Contract. This section covers only general conditions and requirements shall be implemented for control and instruments.

Controls and instruments shall be supplied and installed wherever specified and/or shown on the drawings and shall conform with the followings:

- a. All controls, relays, switches, gauges, instruments, floats, etc,... necessary for the satisfaction operation of each system or equipment shall be supplied and installed whether specifically mentioned or not.
- b. Install control valves horizontally with drive up.
- c. Reading instruments and gauges shall be provided with adjustable marker to set normal operating figure.
- d. Unless specifically mentioned otherwise, controlled, variables shall be maintained within the following limits of the set point:

Temperature : $\pm 2^{\circ}$ F (1° C)

Pressure and Humidity: ± 5 per cent

Water levels ± 3 per cent

- e. Where adjustments and calibrations of controls and instruments are specified and/or provided, they shall be installed to allow for access facility.
- f. Wall mounted controls and instruments shall be fixed at normal eye-sight level and securely fixed in place in accordance with manufacturer's recommendations.
- g. Control voltage shall not exceed 220 volts.
- h. Shop drawings submit for approval complete control and wiring diagrams for control systems intended, showing all control instruments, auxiliaries and accessories.
- j. Accessories and appurtenances: Provide as necessary and appropriate to accomplish intended control functions, irrespective of whether or not shown or specified, such as switches, relays, transformers or other.
- k. Control wiring and conduits: Provide as necessary and appropriate for complete control system and conforming to requirements of Section 15030 Electrical Works for Mechanical Systems. Make all necessary connections to controls and equipment.
- l. Indicating instruments such as pressure gauges and thermometers are shall have range such that normal readings are indicated in middle of instrument range.
- m. Indicating instruments installed on insulated pipes are shall have necks to extend instrument to final finished insulation surface.
- n. Separable socket wells for immersion thermostats and thermometers are shall be brass, threaded and of size and length to suit instrument and pipe.
- p. Manufacture: control instruments and appurtenances are shall be the product of one manufacturer, of latest design and as recommended by manufacturer for control systems intended. Controls are shall be supplied for local electric current, unless noted otherwise.
- q. Wall mounted thermostats: install 1.5m above floor level on inside wall and where temperature at thermostat is not affected except by room temperature.

- r. Immersion thermostats and thermometers shall have bulbs inserted in brass separable socket wells installed vertically or at an angle. Socket wells are shall be installed through female threaded steel fittings welded to pipe. Insertion depth is to suit pipe.
- s. Controls shall be electrical or electronic type as indicated.

B. Calibrations and Adjustments

After completion, controls and instruments shall be calibrated and adjusted to ensure that systems controlled or monitored by them operate satisfactory and in conformity with the Specifications and their intended functions.

Whenever controls and instruments complexity dictates, the Contractor shall provide, at his expenses, an Engineer from the Manufacturer for calibrations and adjustments.

C. Temperature Controllers

- 1. Room Thermostat: to provide line voltage, on-off control of fan coil unit valve and fan through spdt switching having the following features:
 - wall mounted, with silver bronze finish and moulded cover
 - manual fan speed and on/off selection (on/off -lo-med-hi)
 - horizontal temperature scale range with set point control lever
 - provision to break cooling circuit when fan is off
 - range approximately 40-90 deg. F with fixed differential of 2 deg. F
 - accessories including outlet box and adjustable range stops.
- 2. Return Air Duct Thermostat and Temperature Controllers: to provide line voltage, proportional control of damper or valve motor through sensing element and capillary adjusting potentiometer in proportion to temperature variations having the following features:
 - set point adjustment knob on dial
 - differential adjustment dial with 135 ohms resistance potentiometer
 - liquid filled, fast response coiled capillary element for duct applications or sensing bulb with immersion well components for chilled and heating water pipes applications
 - 6 meters copper capillary tube
 - range 55-175 deg. F with adjustable proportioning range of 3-30 deg. F
 - accessories including controller mounting, capillary holder for mounting sensing element in air duct or immersion well assembly with compression fitting and tube clip for mounting bulb in tank or with T-strap for clamping bulb on pipe.
- 3. Low Limit Thermostat and Temperature Controller Type T-3: to provide line voltage, on-off control of damper or valve by sensing temperature of air in duct or liquid through an spdt switch. Type having the following features:
 - set point adjustment knob on dial
 - differential adjustment dial with snap-acting switch
 - liquid filled, fast response coiled capillary element for duct applications and sensing bulb with immersion well components for pipe applications

- 6 meter copper capillary tube
- range 55-175 deg. F with adjustable differential of 3-10 deg. F
- accessories including wiring knock-outs, controller mounting, capillary holder for mounting sensing element in air duct with bag assembly or immersion well assembly with compression fittings and tube clip for mounting bulb in tank or with T-strap for clamping bulb on pipe.

D. Motorized Valves and Actuators

1. Motorized Valves : line voltage, 3-way, 2-position type providing diverting control of water flow through solenoid motor actuator in response to signal from spdt controller. Valves having the following features:
 - all brass, with flare fitting ends
 - integral motor-actuator removable from valve body without draining system
 - manual opener for operation on power failure
 - rated 125 psi, 200 deg. F maximum water temperature, 125 deg. F maximum ambient temperature, opening or closing time 30 seconds
 - accessories including end-switch enclosure.
2. Motorized Valves: low voltage, 3-way, mixing, proportional reversing type, providing modulating control of water by-pass flow through operation of motor actuator and valve linkage in response to signal from proportional controller. Valve having the following features:
 - valves 1/2" to 2" sizes, with two inlets and one outlet screwed end connections, cast bronze body, stainless steel stem, brass plug, integral brass seat and spring loaded, self-adjusting, Teflon cone packing
 - valves 2 1/2" and larger, with two inlets and one outlet flanged end connections, cast iron body, stainless steel stem, brass plug, replaceable bronze seat and spring loaded, self-adjusting, Teflon cone packing
 - reversing type motor, oil-immersed gear train, die-cast aluminum case, single 160 degree stroke, double-ended crankshaft, die-cast aluminum cover with built-in transformer and direct drive feedback potentiometer
 - linkage directly mounted on motor, without adjustment requirements and comprising roller, slide mechanism, cam and stem position indicator and with 150 lb. seal-off force
 - valve rated 250 deg. F maximum water temperature and 150 psi maximum water pressure
 - motor rated 125 deg. F maximum ambient temperature.

E. Sequence Controllers

1. Sequence Controller: to provide sequence control for multiple water chiller units or multiple boiler units according to the preset temperatures and provide programmed permutations for lead / lag chillers or boilers for equal use. Advanced proportional plus derivative microprocessor control algorithm, with the required number of steps for 3 water chiller units and for 2 water boiler heating units. Shall be used with electronic temperature sensors.

F. Sensors**1. Temperature Sensor**

To provide proportional single output for electronic temperature controller. Type having the following features:

electronic type

insertion or immersion type for mounting on air duct or liquid line

set point range -40 to + 257°F

accessories including 125 to 450mm insertion element for duct mounting and 100mm immersion element with pressure rating for 150 psi for liquid line mounting.

2. Humidity Sensor -

To provide proportional or proportional plus integral control action, electronic type. Range 15-90% RH with adjustable throttling range 1-10% RH.

3. Flow Switch

To shut off water chiller when water flow through chiller drops to preset quantity. Type similar to McDonnel and Miller model FS 4-3 or approved equal and having the following features:

pedal vane type with single-pole, double-throw contacts

flow sensitivity adjustment.

G. Instruments**1. Thermometer**

Mercury in glass type, minimum 6 inch long, with brass protective cover and brass separable socket well and graduated in Fahrenheit with 2°F divisions. Obtain from one of the following:

2. Pressure Gauge

Bourdon tube type, minimum 100mm dial diameter, with flangeless back and 12.7mm male threaded bottom connection and graduated in PSI with 2 PSI divisions. Gauge shall have black finished cast aluminum case, threaded black epoxy cast aluminum ring with gasketed glass face, type 316 stainless steel spring tube, stainless steel precision movement and micrometer adjustment on needle.

MEDICAL GAZ INSTALLATION (15960)

General

All works detailed should be carried out by a company, or under the direction of a company, with ISO accreditation to ISO 9001: 1994 Quality Assurance Schedule for:

- The Design, Manufacture, Supply, Installation, Commissioning and servicing of Industrial and Medical Pipelines and Distribution Systems for use with gases.
- Supply, Installation and Commissioning of Associated Plant and Alarm Systems for use with the above, including the associated electric wiring.

A copy of above mentioned certificate should be presented.

All works will be completed with the minimum disruption to existing services and shall be in strict accordance with the medical gases permit to work.

After completion of works a compliance certificate should be submitted. The company that will carry out the testing and commissioning must be certified to do such work. A copy of the permit must be presented. All expenses for such a company shall be paid by the contractor.

A. Medical compressed air plant

A. General

The compressed air plant shall be of modular construction and designed so that all

major components are at least of duplex configuration.

Air shall be provided by air plant capable of providing a net flow-rate (F.A.D.) as described in the schedule of capacities with one pump not running and after dryer losses. The plant shall consist of two identical air compressors and one receiver and a duplex filter/dryer module.

B. Standards

The air compressors shall be of proven reliability and shall be driven by electric motors to Class F insulation and noise levels tested to BS 4999. The receiver vessel shall be constructed and tested to EN 286 or BS 5169 / 1975 Class 3 Grade E. The control panels and electric installations shall conform to the latest IEE regulations and the starters are to BS 4941.

C. Air Compressors

A total of two identical single stage reciprocating air compressors shall be provided each directly driven by an electric motor and incorporating an air inlet filter and silencer. Each compressor shall be provided with air-blast after-coolers and auto/manual drains. The compressor electric motors shall be squirrel cage type suitable for a 380 volt ac three phase 50 Hz supply - with a DOL starter. Capacity as shown on the schedule of equipment

The air compressor, after-cooler and control circuitry must be mounted on a single skid.

The compressor should be oil lubricated, single stage reciprocating type. The unit must incorporate a high volume fan, cooling ring, after-cooler. Air inlet filter and a silencer. The compressor must have the additional benefit of requiring an oil change every 2000 hours or twelve months whichever is the shortest period.

A separate fused 3 phase supply is required for each compressor.

Each after-cooler is operated by an air blast from a motor driven fan. The after-cooler assembly includes an automatic drain with manual by-pass and forms part of the compressor control assembly. Additional components are also mounted on the after-cooler framework: the dump solenoid valve and silencer, fail to load pressure switch, temperature switch, non-return valve, isolation and safety valves.

D. Receiver Vessel

One No. Vertically mounted welded steel receiver vessel shall be provided with an access panel to enable full internal inspection . the total vessel capacity will be as shown on the schedule of equipment. The receiver shall be protected by a pressure relief valve and fusible plug. Which melts if combustion should take place either internally or externally to the receiver. The receiver is fitted with an automatic drain with manual bypass to remove moisture / condensation.

E. Filter Dryer Assembly

Air delivery must be via a duplexed sets of filters; pre-filter, oil filter, dust filter, activated carbon filter and bacterial filter. Each filter shall be fitted with differential pressure gauges to monitor filter performance.

The air shall contain no more than:

- Water 115mg/m³
- Dry Particulate 0.01mg/m³
- Oil mist < 0.01mg/m³
- Oil vapor <0.03mg/m³
- Carbon monoxide 5.0mg/m³ 5ppm v/v
- Carbon dioxide 450mg/m³ 500ppm v/v

Duplex desiccant dryers shall incorporate a dew point alarm system.

Each dryer must have a double absorber, are heat-less and filled with activated alumina desiccant. The absorbers are automatically reactivated on a timed cycle.

The high specification of the dryer means that it will perform equally well in temperate as well as hot climates.

The modules must also incorporate the dump valves and silencers. All maintenance, including desiccant changes can be done in-situ.

The dryer operation must be completely automatic with full control from its own dedicated, easy to read, control panel. The control panel must have individual failure indication if either a high dew point fault or low pressure fault occurs. In this event the standby dryer must be automatically selected and an alarm condition initiated.

The dryer control panel must be linked to the central control panel to ensure no purge losses in a non-demand situation. In the event of a power failure to the dryer all solenoids open to maintain a supply of air to the distribution system.

The dryer control panel can be programmed to give purge cycles suitable for any climate. A "fast forward" feature enables the dryer cycle shall be checked in seconds.

All filters and dryers must be duplexed and the system must be with non-return valves and ball valves to carry out filter changes without affecting the supply of air to the hospital.

F. Control Panels

A dedicated control panel shall be provided, for each air compressor, to house the isolating switch, starter, MCB, ammeter, hours run meter, lead compressor selection switch, pressure switch, alarm and BMS contacts.

Under normal conditions the capacity of the plant shall be 100% system design flow with one compressor not running. A pressure transducer shall sense the pressure and operate logic circuits within the control panel to switch the lead compressor on or off, maintaining the design flow. A digital readout of vessel pressure shall be located on the central control panel door capable of being switched to show pressure in Kpa, psi or bar. During periods of peak demand the lag air compressor shall automatically be activated to operate in addition to the lead compressor.

The compressor shall automatically shut down once pressure levels have been restored. In the event of a lead compressor failure, the lag compressor shall take over and the first stage of the remote alarm system shall be activated. In the event of all compressors failing the second stage remote alarm shall be activated by the control panel. Should the primary control circuit fail an independent system with a separate mechanical back-up switch will operate the compressors and also initiate a plant fault alarm.

The air plant shall have four stages of alarm conditions inputting to the alarm system as follows:

1. Plant faults caused by: Control circuit failure. Activation of any other safety device or failure of a selected compressor to run up to speed on time.
2. Plant Emergency caused by: Low receiver pressure fault (0.5 bar below cut-in pressure of the lag compressor or 0.5 bar above cut-out pressure of the lead compressor). Dew point above -26°C at atmospheric pressure.
3. Reserve fault caused by: Reserve manifold pressure less than 50%.
4. Pressure fault caused by: Low pipeline or high pipeline pressure.

Building Management Systems contacts shall be: (Normally Open or Normally Closed Contacts)

Plant Fault, Plant Emergency, Reserve Fault and Pipeline Pressure Fault.

G. Plant Central Control Unit

The central control panel should automatically matches the demand with selection and rotation of the lead pump. A transducer controls the cut-in, cut-out settings for the lead and lag compressors and has a mechanical back-up in the event of a malfunction. The central controller can operate up to four pumps so the plant capacity can be field expandable at a later date. An electronic watchdog monitors the central processor and will indicate a plant fault in the event of a malfunction. For additional safety all voltages within the central control panel must be less than 30 volts.

H. Motor Control Unit

Each pump must be fitted with a dedicated motor control unit. This incorporates a three phase and neutral isolator, ammeter, motor circuit breaker, starter, hours run meter, pressure switch and indicating LED's for the following pump status:

- a. Normal
- b. Control circuit failed

- c. Overload tripped
- d. Failed to go on load
- e. After-cooler temperature high
- f. Running
- g. Power on
- h. Hand control
- i. Auto control

The digital pressure readout can be set in Kpa, psi or bar on site. The control panels must be simple to maintain and to fault find. The central control unit must houses the main PCB, transducer, mechanical back-up switch and LED indication for the following:

- a. Power on
- b. High demand
- c. Compressor status; lead, running and failed
- d. Vessel pressure level in Kpa, psi or bar
- e. Auto or manual selected

Plus the following alarm condition:

- a. Normal
- b. Plant fault
- c. Plant emergency
- d. Reserve cylinders low
- e. Pipeline Pressure fault

No-volt normally closed contacts must be available for the above conditions, in addition Normally Open (N/O) or Normally Closed (N/C) BMS contacts must be also available for conditions (b) to (e).

H. Motor Control Unit (cont'd)

In addition to BMS connections in each starter:

- a. Control circuit failed
- b. Overload tripped
- c. Failed to go on load
- d. After-cooler temperature high

B. Medical vacuum plant

A. General

Medical vacuum shall be provided by vacuum plant capable of providing a flow-rate shown on the schedule of equipment, of free air aspired at a vacuum of 450mm hg (gauge) with one pump not running. The plant shall consist of two identical vacuum pumps and one receiver.

B. Standards

The vacuum pumps shall be of proven reliability and shall be driven by electric motors to Class F insulation and noise levels tested to BS 4999. The receiver vessel shall be constructed and tested to EN 286 or BS 5169/1975 Class 3 Grade E. The control panels and electric installations shall conform to the latest IEE regulations and the starters are to BS 4941. The bacterial filter element guarantees bacterial removal to 0.005% when tested to BS 3928 at full hospital design flow. Drainage trap bowls and bacteria filter bowls shall be suitable for sterilization. The Medical vacuum plant must be capable of maintaining a vacuum

of at least 300mm Hg at the connection point of each terminal unit with a flow of 40 l/min whilst operating at system design flow.

C. Vacuum Pumps

The vacuum pumps shall be air cooled, oil flooded rotary vane directly driven by a 380 volt, three phase 50 Hz electric motor. The pump inlet shall be filtered and the exhaust shall incorporate an oil filter. Each vacuum pump and associated pipe-work shall incorporate non-return valves to protect both the vacuum system and receivers from inadvertent pressurization.

D. Receiver Vessel

One No. floor mounted welded steel receiver vessel shall be provided with inspection access panel and manual drain. The total vessel capacity will be as shown on the schedule of equipment.

E. Bacterial Filter Assemblies

Flow passes through a duplex system of bacterial filters fitted with manual isolating valves to permit duty and standby operation. Each bacterial filter must have a replaceable element and fitted with a sterilisable moisture drainage bowl with isolating cock and differential pressure indicator. When the indicator reads 100 mbar the element needs changing. The system ensures bacterial removal to 0.005% when tested to BS 3928 at full hospital design flow. The pressure drop through a clean filter passing the system design flow rate will not exceed 25 mm Hg.

F. Control Panels

A dedicated control panel shall be provided, for each vacuum pump, to house the isolating switch, starter, MCB, ammeter, hours run meter, hand/auto switch, vacuum switch, alarm and BMS contacts. Under normal conditions the capacity of the plant shall be 100% system design flow with one pump not running. A transducer shall sense the vacuum level and operate logic circuits within the central control panel to switch the lead pump on or off, maintaining the design vacuum level. During periods of peak demand the lag vacuum pump shall automatically be activated to operate in addition to the lead pump.

The pump(s) shall automatically shut down once vacuum levels have been restored. In the event of a lead pump failure, the lag pump shall take over and the first stage of the remote alarm system shall be activated. In the event of all pumps failing the second stage remote alarm shall be activated by the control panel.

Should the primary control circuit fail an independent system with a separate mechanical back-up switch will operate the pumps and also initiate a plant fault alarm. The vacuum plant shall have three stages of alarm conditions inputting to the alarm system as follows:

1. Plant Faults caused by:
 - Control circuit failure.
 - Activation of any other safety device or failure of a selected pump to run up to speed on time.
2. Plant Emergency caused by:
 - Low receiver vacuum (50mm Hg above cut-in pressure of the lag pump(s)).
3. Pressure Fault caused by
 - Pipeline vacuum less than 360mm Hg.

Building Management System contacts shall be:

(Normally Open or Normally Closed contacts)

Plant Fault, Plant Emergency, Pipeline Pressure Fault.

G. Plant Central Control Unit

The central control panel must automatically match the demand with selection and rotation of the lead pump. A transducer controls the cut-in, cut-out settings for the lead and lag pumps, as well as the low vacuum alarm. Mechanical back-up in the event of a malfunction is a must.

The central controller must be capable to operate up to four pumps so the triplex module package plant capacity can be field expandable at a later date.

An electronic watchdog to monitor the central processes is a must and will indicate a plant fault in the event of a malfunction. The central control panel must contain only 12 volts dc.

The central control unit must house the main PCB, transducer, mechanical back-up switch and LED indication for the following:

- a. Power on
- b. High demand
- c. Pump status; lead running and failed
- d. Vacuum level in mm Hg
- e. Auto or manual selected

Plus the following alarm conditions:

- a. Normal
- b. Plant fault
- c. Plant emergency
- d. Pipeline pressure fault

No-volt normally closed contacts must be available for the above conditions, in addition Normally Open (N/O) or Normally Closed (N/C) BMS contacts must be also available for conditions (b) to (d).

H. Motor Control Unit

Each pump must be fitted with a dedicated motor control unit. This incorporates a three phase and neutral isolator, ammeter, motor circuit breaker, starter, hours run meter, vacuum switch and indicating LED's for the following pump status:

- a. Normal
- b. Control circuit failed
- c. Overload tripped
- d. Failed to go on load
- e. Running
- f. Power on
- g. Hand control
- h. Auto control

In addition BMS conditions:

- a. Control circuit failed
- b. Overload tripped
- c. Failed to go on load

C. Manifold systems

A. Main Supply Manifolds

The manifold system shall incorporate a one piece control panel, manufactured from a solid construction using latest RTM epoxy technology in GRP molding with a hinged form panel to facilitate easy maintenance. The unit shall be suitable to withstand extreme temperatures without any degradation or weakening. All internal wiring shall be 12V DC for safety purposes, with the PCB connected with plug and socket connections for easy maintenance. It shall enable fully automatic operation, selecting duty and standby banks by automatic detection, the unit will be provided with a manual change over button so that the duty and standby banks can be selected manually. The manifold control panel shall comprise two stages of regulators suitable for a flow rate of 0 - 2000 l/m at 7 bar (whilst maintaining a pressure of +/- 0.5%). For Oxygen and Nitrous Oxide the manifolds shall be set at a distribution pressure of 4.1 bar. Pressure relief valves for both intermediate and final pressure shall be capable of passing the total maximum flow and both systems shall be piped to atmosphere. A by-pass valve shall be installed for decompression and commissioning purposes with the vent piped directly into the relief valve exhaust.

The header assembly shall be wall mounted each cylinder shall be connected to the header by means of a flexible cupro-nickel tailpipe. The header shall be fitted with a non return valve for each tailpipe and be gas specific to prevent tailpipes for other gases being fitted. The header shall fit directly to the control panel with a high pressure mechanical connection.

The manifold will have the capability of transmitting signals into the main alarm system as follows:

1. Change Cylinders: This condition will occur when either the left or right hand bank (the automatically detected duty) is empty and the manifold has changed over to the other bank (standby).
2. Change Immediately: The second condition will be activated when the standby bank has been depleted (both banks empty).
3. Reserve Fault: Will be activated when the level of the gas in the emergency standby manifold has fallen to 50% capacity.
4. Pressure fault: Caused by a pressure fluctuation on the main supply from the manifold (line pressure) of any greater than +/- 10 - 15%.

B. Emergency Standby Manifold

Each main supply manifold shall have an emergency standby manifold (ESM) fitted to manually take over the supply of gas in the event of emergency or total manifold replacement. The ESM will be fitted with the same tailpipes as the main manifold.

The pressure in the cylinders shall be monitored by a high pressure switch which will relay a signal to the main control panel in the event of a reduction in pressure to 50% normal (Oxygen and Air) or 90% normal (Nitrous Oxide). This signal shall be displayed on the Main Manifold Control Panel and be retransmitted into the main alarm system.

Each manifold will be supplied with support racks with cylinder retaining chains, headers and tailpipes for both duty and reserve banks, as well as a spare rack for wall mounting with retaining chains to hold cylinders for the duty bank.

C. Capacities

Oxygen will be supplied from a 2 X 5 manifold complete with Manifold Control System (MCS) Panel & 2 cylinder emergency supply manifold (ESM).

Nitrous Oxide will be supplied from a 2 X 2 manifold complete with MCS panel & 2 cylinder ESM.

Emergency Air supply at 4. bar and 7 bar will be supplied from a 2 X 2 cylinder ESM.

D. Labeling and Location

All MGPS accommodation should be clearly labeled as to their purpose. For example, cylinder stores should be labeled with the type of cylinders contained. Details of emergency action procedures and location of keys should be posted, as should no smoking and other warning signs such as no parking sign (in the vicinity of the delivery and storage areas). Separate clearly identified bays should be provided for full and empty cylinders which are shall be stored in racks. Separate areas for different categories of gases should be provided, but it is not necessary to construct a physical barrier unless it is convenient to do so. Adequate means of securing cylinders to prevent falling should be provided.

All manifolds, including the emergency reserve manifolds may be located within the same room and should not be in the same room with medical air compressors or vacuum plants.

D. Alarm system

Two alarm systems shall be used, the Central Alarm System for plant and supply equipment monitoring, and a Local Area Alarm System for monitoring the condition of gas down stream of the final isolation valve.

A. Main Alarm System

The main alarm system shall have a capacity for 5 gases with each gas display capable of displaying normal and 4 fault conditions. In general the conditions will be as mentioned in the plant and manifold systems as detailed above, and legends will be pre-printed as standard.

The alarm panel shall display flashing lights corresponding to the fault in question together with an audible signal. The alarm fault can be accepted at the panel at which time the flashing light will steady and the audible alarm shall mute. If the cause of the fault is not corrected within 15 minutes the alarm system will reset and the flashing lights and audible signal will resume.

In the event of long term shut downs or faults with plant the alarm can be set to accept the existing faults as a maintenance item. As soon as the maintenance "fault" has been normalized, the alarm will automatically reset to normal operation.

All system alarm cabling between the alarm panels, and between alarm panels and plant or manifolds, shall be monitored so that the system can detect a wiring fault, open or short circuits. This fault shall be displayed on the alarm panel as a "system fault" and the panel will be to detect in which area the fault exists and the type of fault.

Main alarm panels shall be positioned at the following locations:

1. Plant Room
2. Manifold Room
3. Telephone Switchboard

B. Local Area Alarm System

The local alarm panel shall have a capacity of up to 5 gases with each gas display capable of displaying normal and 2 fault conditions. As standard the conditions will be Normal, High Pressure and Low Pressure, and legends will be preprinted as standard.

The alarm panel shall display flashing lights corresponding to the fault in question together with an audible signal. The alarm fault can be accepted at the panel at which time the flashing light will steady and the audible alarm shall mute. If the cause of the fault is not corrected within 15 minutes the alarm system will reset and the flashing lights and audible signal will resume.

In event of long term shut downs or faults with plant the alarm can be set to accept the existing faults as a maintenance item. As soon as the maintenance "fault" has been normalised, the alarm will automatically reset to normal operation.

All system alarm cabling between the alarm panels and pressure switches, shall be monitored so that the system can detect a wiring fault, open or short circuits. This fault shall be displayed on the alarm panel as a "system fault" and the panel will be able to detect in which gas the fault exists and the type of fault.

Area alarm panels shall be positioned downstream of the final area valve service unit or line in each department.

E. Area valve service units (AVSU)

The AVSU shall be positioned at the entrance to each ward or department and shall provide a zone isolation facility, for use either in an emergency or for maintenance purpose. A physical barrier (spade) shall be capable of insertion when required on either side of the valve, without the need to totally dismantle the line valve. The ZSU shall be fully gas specific, permanently labeled to identify the medical gas service and shall incorporate a gas specific Non Interchangeable Screw Thread (NIST) connection on each side of the valve. Pressure gas services (not vacuum) NIST connections shall incorporate 100% self sealing valves which are normally held closed by gas pressure.

The line valve shall be a brass 22 or 42mm ball valve with PTFE seal/seats, operated by a quarter turn handle with a pin to prevent over traveling both directions. The ball valve shall connect by 22 or 42mm stub pipes to the distribution system (for 22mm connections, at either top, bottom, side or rear entry pipes).

The assembly shall be housed in a self extinguishing ABS valve box which shall be capable of both surface or concealed installation. The whole of the ZSU shall be mounted on a stainless steel back-plate.

The valve box shall incorporate a hinged lid which opens through 180 degrees, to provide maximum access. The hinged door shall be fitted with a glass panel to enable a visual check on the line valve selected position and access in an emergency via a strike button to enable easy shattering of the glass.

The glass itself shall shatter into small pieces so that no sharp edges can cut the operator. The hinged door shall normally be locked closed and ZSU's installed adjacent to each other shall be operated by different key/lock combinations.

The ZSU assembly shall provide for natural ventilation to prevent any localised build up of gas within the valve box.

F. Area service module

The Area Service Module shall be wall mounted or recessed and shall be constructed of internal metal bracket's aluminum framework and extruded aluminum clear anodized sections. Panel shall be manufacture from 9.52mm fire retardant particle board with Formica high pressure laminate backing and facing sheet. Each panel shall be edge-banded with an anodized aluminum extrusion strip, retained by self tapping cadmium plated screws with a snap-in filler and retainer strip. An easily removable panel shall be provided to enable access to the electrical fused connection unit and the pressure/vacuum switch assemblies.

The Area Service Module shall contain a medical gas alarm panel (including pressure switches) and up to five area valve service units (AVSU).

Medical gas/vacuum service shall be fixed copper piped to and from their respective area valve service unit and shall normally terminate in 22mm copper stub pipes connected at ceiling level.

Pressure / vacuum switch assemblies shall be installed as bank mounted on an internal mounting frame and connect to their respective gas service down stream of the area valve service units.

A 3amp fused connection unit shall be provided for the mains electrical power supply. Electrical cable from the connection unit to the medical gas alarm panel shall be and routed and secured clear of the medical gas/vacuum services, and the complete electrical installation shall conform to IEE regulations. All metal components within the module assembly shall be electrically bonded and the installation shall be earthed.

The Area Service Module if shall be wall mounted shall be factory pre-wired, pre-piped, completely assembled and tested ready for installation prior to dispatch. A testing certificate from the manufacturer shall be issued and presented for each area service module before installation. The certificate should be issued by a recognized company to ISO 9001, quality assurance .

The Certificate shall indicate the S/N of the module, S/N of the alarm panel and S/N of the area valve service units, date and place of test along with the name of the tester with his signature.

An operating and maintenance manual shall be provided.

G. Line ball valve assemblies

Medical gas line ball valve assemblies shall be constructed of a nickel plated brass body, PTFE seats/seals and a brass chrome plated ball. The valve shall operate by a manual operating lever selected through 90 deg. All medical gas line ball valves shall provide a full bore flow and shall be cleaned for oxygen service and fully tested prior to dispatch. Smaller valve assemblies (15 to 42mm inclusive) shall incorporate stainless steel 'Dowty' bonded seals and mechanically sealed connectors. Larger valve assemblies (45 to 108mm inclusive) shall be flanged, installed with stainless steel bolts, nuts and spring washers with 3mm Viton sealing gaskets. In all cases, the use of PTFE tape or any other thread sealing medium shall not be used during installation.

Each medical gas line ball valve assembly shall terminate in copper stub pipes to enable brazing direct into the distribution system using the fluxless brazing technique with Nitrogen Purge.

A locking device shall be provided and enable the valve shall be locked in either the fully open or fully closed position.

A certificate of compliance should be presented.

H. Piped distribution system

- A. The piped distribution system shall use copper pipes manufactured from phosphorous de-oxidized non-arsenical copper (Grade C106) and be manufactured to metric outside diameters. Pipes shall be shot-blasted and degreased suitable for oxygen use and cleanliness shall be maintained by suitable end caps and protective wrapping.
- B. Fittings shall be end feed type, manufactured from the same grade of copper as the pipes.
- C. Copper to copper joints shall be made on site using a copper phosphorous brazing alloy type CP1 or CP4 using an internal nitrogen inert gas shield without the use of flux. Copper to brass or gunmetal joints shall not be made on site.
- D. Pipelines shall be supported at the intervals specified in HTM 2022 using a suitable metallic, non-ferrous material suitably treated to prevent corrosion and electrolytic action. Plastic supports may be used only for the down drops to the terminal units.
- E. Medical pipelines should be kept away from areas where they may be subject to any of the following:
 - a. Mechanical Damage
 - b. Chemical Damage
 - c. Excessive Heat
 - d. Splashing, dripping or permanent contact with oil, grease or bituminous compounds, electrical sparks,.....
- F. Exposed pipelines should not be installed in lift shafts, kitchens, laundries, boiler houses, generator rooms, incinerator rooms, storage rooms designed to house combustible materials or in any other fire-risk area.
- G. Pipelines should be protected from the possibility of lightning strikes.
- H. Buried pipelines should be run in a trench not less than 450 X 450mm with the pipe protected throughout its length by a continuous glazed earthenware pipe or carried in properly drained ducts with removable covers. These glazed pipes or ducts should be further protected where the pipe crosses areas used by wheeled traffic. In such areas the glazed pipes and ducts should be encased in concrete. Multi-way ducts should be used where more than one pipe is to be carried. The route of the pipeline should be identified on the surface and should be clearly shown on site lay out drawings. Pipelines should not be buried solidly in walls or floors, and any joints should be kept to the minimum practicable
- J. Identification of pipelines
Pipelines should be identified in accordance with BS 1710 and color banding for the pipelines should be used outside the plant room. Color band identification should be applied near to valves, junctions, walls, etc.. Each gas should be identified in 6mm letters. Self-adhesive plastic or clip-on labels of approved manufacture may be used for this purpose. A band 150 mm wide is usually adequate. All color coded tapes applied by the pipe manufacturers should be removed before the systems are identified in accordance with this paragraph. The direction of flow should be indicated.

J. Terminal units

A. General

Terminal units shall be available as outlets on piped Medical gas distribution systems for the following Medical gas services: Oxygen, Nitrous oxide, Medical air 400 Kpa, Medical air 700 Kpa, and Medical vacuum. Units are gas specific and may be sited in any location within a hospital. Terminal units shall be available for wall or bed head mounting and used in Pendant installations.

B. Standards

The medical gas terminal unit shall conform to international Standard 9170 and the following:

The wall mounted first fix assembly shall consist of a brass pipeline termination block with copper stub permanently secured between a back-plate and a gas specific plate which allows limited radial movement of the copper stub to align with the pipeline. The first fix shall incorporate a maintenance valve (except for vacuum) and a test plug. The test plug provides an effective blank to enable carcass pressure testing. The second fix plastic components shall be molded from fire retardant polycarbonate with the index pin permanently molded into the gas specific socket. The socket assembly retains a capsule assembly, a sealed unit containing the check valve and probe 'O' ring seal. This replaceable capsule assembly enables all working parts subject to wear and tear through usage shall be replaced as a factory tested assembly. Medical gas terminal units shall accommodate variable plaster depth of up to a maximum of 16mm.

Terminal units shall be gas specific and only accept the correct medical gas probe. Gas specific components shall be pin-indexed to ensure that a correct gas specific assembly is achieved so that in the normal course of dismantling for repair or maintenance, parts from other gases cannot inadvertently be used. Wall mounted terminal units shall incorporate an anti-rotation pin to engage with connected downstream medical equipment ensuring correct orientation.

Terminal units shall be designed to allow easy and accurate installation and shall be supplied with installation instructions and a comprehensive Operating and Maintenance manual.

Terminal units installed in pendants shall be attached to their respective flexible hose by a gas specific NIST fitting and anti-rotation pins shall not be fitted.

Terminal units located in a rigid installation shall be capable of single handed insertion and removal of the correct medical gas probe. The terminal units shall have a 3 year warranty, subject to the recommended minimum routine maintenance operations being carried out by correctly competent persons.

C. Description

1. First Fix Assemblies:

Wall mounted first fix assemblies shall be suitable for surface, concealed, or bed head trunking installations and supplied for either horizontal or vertical pipe entry. With vertical pipe entry, entry may be either from the top or bottom and with horizontal pipe entry, entry may be either from the left or right hand. The first fix assembly consist of a brass pipeline termination block with copper stub pipe, to enable brazing directly to the distribution system using the approved fluxless brazing technique. Each first fix assembly incorporates a plaster box and plaster shield.

2. Multiple Gas Jig Plates:

To ensure correct alignment and spacing of multiple terminal unit arrays, multiple gas jig plates shall be used to mount the first fix assembly. Jig plate form the foundation for all concealed and if required bed head trunking installations. For ease of installation, multiple gas jig plates are accurately aligned using a purpose built installation jig, and leveling screws enable accurate alignment in both horizontal and vertical planes. With 2 gas service jig plates, a choice of either 133.5mm or 150mm spacing is provided. Multiple gas jig plate dimensions are detailed below:

Jig Plate	Height (mm)	Length (mm)	Chase depth Requirements (mm) (including plaster depth)
2 gas service	95	267	50
2 gas service	95	400	50
2 gas service	95	534	50
2 gas service	95	667	50
2 gas service	95	801	50

3. Second Fix Assemblies:

Second fix assemblies are gas specific and are suitable for all types of installation. The second fix assembly consists of a gas specific socket and index pin assembly complete with fascia ring, and a capsule assembly. The socket assembly retains the capsule assembly within the first fix and is pin indexed to ensure that the installation is gas specific. The capsule assembly is a sealed unit containing the check valve and probe 'O' ring seal. This design enables all working parts subject to wear through usage shall be replaced as a factory tested assembly, the socket assembly is indexed to accept only the correct Medical gas probe. Probe roller pins inside the socket lock the engaged probe in position which opens the check valve and release is only effected by pushing on the fascia ring. An anti-rotation pin is fitted to all horizontally mounted terminal units to ensure correct orientation of downstream equipment. The terminal unit shall be clearly identified and labeled.

4. Fascia Kit:

A fascia kit completes the assembly for both surfaces and concealed wall mounted terminal units. The fascia kit accommodates each terminal unit individually and consists of a plastic fascia plate and a bezel. The bezel is used to cover the plaster join and the fascia plate secures the assembly to the gas specific bracket with two countersunk screws.

5. Bed Head Terminal Units:

Terminal units installed in bed head trunking systems. To ensure correct alignment and spacing, multiple gas jig plates must be installed.

6. Pendant Terminal Units:

Terminal units installed in Flexible, Rigid, pendants. All these terminal units are identical in operation. In each case the pipeline termination block arrangement is specifically designed to suit the required location or mounting arrangement and connects by means of a NIST fitting via a flexible hose to

the distribution system. To ensure easy insertion and removal of a Medical gas probe, terminal units mounted vertically do not incorporate an anti-rotation pin.

D. Performance

Terminal Unit Performance - 400 Kpa Pressure :

Test	
Connection force	50 - 60N
Disconnection force	40 - 50N
Leakage	0.05m1 / min

Pipeline distribution pressure	Terminal unit design flow	Max ΔP across terminal unit	Max ΔP across terminal unit with NIST connectors and 2 meter flexible hose attached to pipe work by NIST fitting
400 Kpa	40 l/m	2.6 Kpa	2.0 Kpa
700 Kpa	250 l/m 350 l/m	30 Kpa 55 Kpa	50 Kpa 100 Kpa
Vacuum 400 mm Hg below atmospheric (760mm Hg)	40 l/m	90 mm Hg	140 mm Hg

E. Installation

Wall mounted terminal units shall be located at a height of 1300mm above finished floor level and shall not be less than 200mm from any possible obstruction. With the exception of 2 gas services of Oxygen and Medical vacuum which are spaced at 150mm between centers, Multi-gas Gem 10 installations shall be spaced at 133.5mm between centers. Wall mounted terminal units shall be mounted, when facing the units, in the following order, horizontally from left to right or vertically from top to bottom: - Oxygen, Nitrous oxide, Medical air 400 Kpa, Medical air 700 Kpa, Medical vacuum. Wall mounted terminal units shall be of exposed type.

F. Testing and Commissioning:

Although the assemblies are fully tested prior to dispatch with a manufacturer certification of compliance it is essential that full commissioning procedures are followed before the systems are brought into use.

K. Pendants

A. Flexible pendant

Flexible pendants shall be supplied and manufactured using reinforced anti-static plastic color coded flexible hose with the appropriate NIST fittings permanently attached. Pressure gas system shall incorporate a self closing shuttle valve in the first fix termination to enable hose removal without disrupting system operation. Medical gas/vacuum services shall incorporate medical gas terminal units. Each terminal unit must be shrouded by plastic cover to minimize the collection of dust or moisture. Flexible pendants shall be manufactured and installed to provide a clearance of 2 meters above finished floor level. The flexible pendant shall

incorporate medical gas and vacuum services as specified: 1 Oxygen, 1 N₂O 1A4, 1A7, 2VAC.

The flexible hoses should be factory assembled and fully tested before dispatch. A manufacturer certificate of quality assurance and compliance should be submitted with each pendant.

B. Rigid pendant

Rigid pendants shall be manufactured using reinforced anti-static plastic color coded flexible hose with the appropriate NIST fittings permanently attached. Pressure gas systems shall incorporate a self closing shuttle valve in the first fix termination to enable hose removal without disrupting system operation. Rigid pendants shall be manufactured and installed to provide a clearance of 2.0 meters above finished floor level.

The mounting surface must be of sufficient strength to withstand a maximum vertical and horizontal load of 300lbs and 225lbs.

The rigid pendant shall incorporate medical gas/vacuum and electrical services as specified. Electrical installations shall conform to IEE regulations, be routed through flexible conduit and terminate in a junction box. The rigid pendant structure shall be octagonal in section and shall be maintenance free and finished in high quality 'easy clean' white enamel paint with a stainless steel fascia soft bumper strip around bottom edge of pendants to protect personnel. The pendant should be factory assembled and fully tested before dispatch. A manufacturer certificate of quality assurance and compliance should be submitted with each pendant.

The rigid pendant shall incorporate medical gas and vacuum services as specified : 2 oxygen, 1 N₂O, 2A4, 1A7, 2VAC and 8 electrical sockets.

L. Testing and commissioning

A. Pressure testing

The test will be during construction and the systems will be pressure tested to a pressure of 10 bar or twice the working pressure, whichever is the greater, the system will then be isolated and the pressure recorded. The pressure reading will be then taken in 24 hours and no noticeable variation will be allowable, with the exception of pressure variation due to temperature fluctuation. If a pressure loss is detected, then the leak will be found, repaired, and another test applied. This will continue until all leaks have been isolated.

B. Anti confusion

Tests will be carried out to ensure that all gases are connected to the correct supplies by; isolating all gases, pressuring each gas in turn, confirming that gas only comes from the pipe marked for that gas and that all other gas pipes are not pressurised

TESTS AND ADJUSTMENTS (15990)**A. Scope**

Execute and conduct all tests to the various systems and services shall be provided under this Contract in accordance with the requirements and instructions of this section.

B. General Requirements

The Contractor shall carry out all tests specified in this section and shall advise the Engineer by writing of the dates of commencements of all tests, partial or final.

Before tests are started, the Contractor shall submit comprehensive information describing tests shall be performed and the methods of testing shall be adopted.

Tests shall be carried out on all equipment, material and accessories supplied and installed by the Contractor.

Tests shall be conducted in compliance with the stipulations of codes of standards mentioned in this Book of Specifications as well as relevant international standard.

The contents of this section are deemed shall be complimentary to, and not in limitations to, the test clauses covered in the General Conditions of Contract of the Civil and Architectural Book of Specifications.

Labor, materials, instruments, power, water, etc..., required for testing shall be provided at no additional cost by the Contractor, unless specifically stated otherwise under the particular section of the Specifications.

Instruments shall include, but not be limited to:

- a. Verniers, calipers, gauges, thermometers, etc...
- b. Voltmeters, ammeters, meggers, etc...
- c. Calibrated air flow meter, pump for hydrostatic pressure tests, etc...
- d. Additional instruments and equipment test that may be required to run the specified tests.

Tests shall be performed in the presence of the Engineer or his representative.

Pressure tests to piping systems shall be applied before their connection to fixtures, equipment and appliances. In no case shall these latter be subject to pressures exceeding their ratings or accepted Engineering Standards of Practice.

Defective Works shall be promptly repaired or replaced and the tests shall be repeated at the Contractor's expenses until the particular system or components receives the Engineer's approval.

The Contractor shall repair and/or replace any damages or damaged materials resulting from the tests at no additional costs.

In the event of any repair or adjustment have shall be made, other than normal running adjustment, the tests shall be void and shall be repeated after the adjustments or repairs have been carried out.

When pipes, valves, ducts, equipment, etc..., are shall be covered, imbedded or insulated, their specific tests shall be carried out on them before any covering is applied. These tests shall not relieve the Contractor of any of his responsibilities, and he shall take all necessary precautions to insure the safety and protection of such tested item or systems until the termination of the Works.

The duration of tests shall be as determined by all parties having jurisdiction, but shall in no case be less than the times prescribed for each system.

Unless specifically stated otherwise in the Specifications, tests results shall not deviate by more than plus or minus five percent of the specified capacities or characteristics.

Three copies of all tests results and data shall be submitted to the Engineer after satisfactory completion of tests.

C. Equipment and Fixtures

The Contractor shall test each equipment or fixture installed under this Contract to ensure that performance and capacities conform with the Specifications.

Equipment and accessories are not shall be subjected to pressure in excess of prescribed test pressure noted in its nameplate data or manufacturer's published data.

Tests: carry out as required to test equipment for performance and proper functioning and to demonstrate, to the Engineer's satisfaction, that equipment meets design requirements.

Retest equipment if adjusted, repaired or replaced.

Data shall be measured shall be those items given on the Schedule of Equipment and including the following: entering and leaving water temperatures, entering and leaving air dry bulb and wet bulb temperature, ambient dry bulb and wet bulb temperatures, air quantities, water quantities, pressure drops on air and water sides, suction and discharge pressures, electric motor horsepower or kilowatt input from measured voltage, current and power factor, sound levels.

The following clauses illustrate tests shall be carried out on various equipment and fixtures; this enumeration shall not limit the Contractor to carry out these tests only. All equipment and fixtures whether mentioned herebelow or not shall be tested to the Engineer's complete satisfaction.

1. Air Handling Equipment

Fans shall be tested for actual CFM and power consumption, phase current and voltage, noise and vibration, interlocks and controls.

2. Cold Generating Equipment (Condensing Units,...)

They shall be tested for power consumption, capacities and conformity of controls with specified sequence of operation, noise and vibration.

3. Air Outlets

Each air outlet shall be tested for actual CFM, air throw and noise.

4. Pumps

Each pump shall be tested for actual flow, actual shut-off head, operating and discharge pressures, rpm, brake horsepower, phase current and voltage and conformity of controls with specified sequence of operation, noise and vibration.

5. Tanks and Vessels

Unless specified otherwise, each tank and vessel shall be tested for leaks under a hydrostatic pressure equal to at least three times its specified working pressure.

Refer to tests on pipes below for testing particulars.

D. Pipes

Unless specifically mentioned otherwise, piping systems including valves, fittings and joints, shall be tested at not less than twice the specified working pressure or ten bars whichever is higher.

Testing procedures shall conform with the following:

- a. Blank-off or remove all traps, instruments, automatic valves, diaphragm valves, relief valves, etc,... or equipment which may be damaged by test pressure.
- b. Open all valves.
- c. Fill the system with the specified testing fluid (water, air, gas, refrigerant,...) and vent it at all high points.
- d. Pressurize the system and maintain the required test pressure for a sufficient length of time to enable complete inspection of joints and connections.
- e. Repair all leaks and/or defects uncovered by the tests and re-test the system.
- f. Maintain test pressure for the specified length of time mentioned under each type of pipe.
- g. After tests have been completed, drain the system and blow-out the testing fluid to clean it of suspended foreign materials.
- h. Clean all strainers, valves and fittings of dirt, fillings and debris.
- j. Do not insulate or conceal piping until tests have been completed and results approved.

Where sections of pipes are shall be covered, imbedded or buried, the required tests shall be carried out on them before they become the covering and the necessary steps taken to protect them until handing over.

1. Refrigerant Pipes

- a. Refrigerant pipes shall be tested at 15 bars for a duration of 24 hours using an inert gas.
- b. After the pressure test is successfully completed, the piping shall be dehydrated and evacuated three consecutive times, each time reaching a vacuum of 100 microns and holding it for a period of three hours and then breaking it with refrigerant gas.
- c. After charging, refrigerant pipes shall be tested by a halide leak detector.

2. Services Pipes (Except Drainage)

Service pipes, except drainage, shall be pressure tested for 24 hours at twice the system operating pressure but not less than 10 bars without loss of pressure.

3. Drainage Piping

- a. Within the building plug piping section shall be tested and fill it at the highest point with water. No apparent loss of water shall be noted after four hours. Tests shall be carried out in floor intervals not higher than ten meters.
- b. Between manholes, pipes shall be tested by plugging the inlet pipe to the upstream manhole and the inlet pipe of the downstream manhole and filling the section with water to the top of the upstream manhole. No apparent loss of water shall be noticed after four hours.

E. Controls and Instruments

Controls and instruments shall be tested to ensure that their performance and functioning is in accordance with the requirements of their particular system and stipulations of the Specifications.

F. Electrical Installation

The Electrical Installation shall be cleaned and adjustments made before applying power. After power is applied, the following tests shall be carried out satisfactorily:

- a. Continuity tests on all wires and cables.
- b. Insulation tests between phases, phase to earth of each circuit as well as equipment by the use of 1000 volts megger. Reading shall be better than 0.5 meghom.
- c. Earth resistance.
- d. Test, panel boards and motor control centers including relays, starters, breakers, switches, etc,...

G. Balancing and Adjusting Air Distribution Systems

Regulate and balance systems to obtain required quantities of supply, return, exhaust and fresh air. Measure air quantities with velometer or anemometer.

Precautions: before operating system for balancing, ensure dampers and registers are open, filters are clean and free of air bypass, moving equipment is lubricated and all necessary inspection and maintenance work is done for proper and safe operation.

Air distribution pattern: set registers and grilles with adjustable bars at correct deflection, as determined from manufacturer's data, to produce required air distribution pattern in space without causing draughts.

Preliminary test run: perform to determine total air quantity delivered by fan at existing system static pressure. Measure air quantity at fan inlet and from each air outlet. Total air quantities measured at outlets shall be within +/-5% of air quantity measured at fan.

Total air quantity delivered is shall be adjusted by regulating fan speed with adjustable motor sheave to obtain specified air quantity. If total air quantity cannot be obtained without exceeding speed range of sheave or available motor horsepower notify the Engineer before proceeding.

Total air quantity: after this is obtained from fan, balance system for required distribution of air quantities.

Test operating devices such as automatic dampers, fire dampers, volume control dampers and splitter vanes for proper, smooth and quiet operation.

Test reports to include duct layouts showing where readings were taken, readings of air quantities as measured for supply, return, exhaust and fresh air, static pressures, details of method of balancing and instruments used.

H. System Reliability and Performance Testing

After successfully completing the above tests, each system shall undergo reliability trial tests for compliance with the specified performances stated in the Tender Documents.

Tests for air conditioning systems shall be between June 15th. and August 30th. and test for heating systems shall be between December 15th. and February 28th. Dates for tests shall be agreed with the Engineer ahead of time.

All other tests shall take place at any reasonable time subject to the Engineer's approval.

The reliability trial tests shall last for a period of seven consecutive days during which all systems and installations shall operate continuously without adjustment or repair to the Engineer's complete satisfaction.

During the reliability tests, performance tests shall be conducted on the various parts or sections of each system. Tests data shall be note and tabulated properly; results less

than ninety five percent of the specified figures shall not be accepted and shall be considered as failing to meet Contract requirements.

Should any part of the various systems or equipment fail to meet Contract requirements, it shall be adjusted, repaired or replaced to the Engineer's satisfaction. Tests shall then be repeated until no faults or adjustments are required.

A taking over certificate or certificate of completion, with or without reservations, will be issued by the Engineer upon satisfactory completion of tests. The taking over certificate with reservations will be issued only if reservations are of minor importance and do not affect systems' used and satisfactory operation.

Scheduling of tests: one month before date set for commencing tests, submit for approval six copies of test procedure with tests shall be performed, method of testing, instruments shall be used, points of measurement and method of calculation. Date for commencing tests shall be subject to approval obtained at least 5 days before each trial test run.

Test results: provide six copies for approval. Include approved copies in the Instruction Manual.

Acceptance certificate shall be drawn up in 3 copies when all tests are carried out to the Engineer's satisfaction. Certificate shall be signed by the Engineer and the Contractor and one copy handed to the Contractor.

LIST OF MECHANICAL APPROVED MATERIALS

ITEM	MATERIAL
1. STEEL PIPES	DALMINE
2. ACCESSORIES FOR STEEL PIPES	CRANE, AFL
3. POLYPROPYLENE PIPES	POLY MUTAN, FUSIOTHERM
4. UPVC PIPES	OMNIPLAST, DALMINE
5. COPPER PIPES	KABEL METAL, WEDNESBURY
6. ACCESSORIES FOR UPVC PIPES	ZURN, REDI, NICOLL, SITA
7. MANHOLE COVERS AND GRATING	PAM.
8. SUPPORTS	GRINNELL, WALRAVEN, MUPRO
9. VALVES, STRAINERS	HATTERSLAY, CRANE, VAG, ISI, NIBCO, SERSEG, JENKINS, BRAUKMAN, PEGLERS
10. PRESSURE REGULATING VALVE	ZURN, O.C. KECKLEY, WATT, BELL & GOSSET
11. AUTOMATIC AIR VENTS	BRAUKMAN
12. WATER HAMMER ARRESTORS	JOSAM, ZURN
13. FLEXIBLE CONNEXIONS	MASON, ANACONDA, FLEXONICS
14. THERMAL INSULATION	ARMAFLEX, FRANCE AIR, FIBER GLASS, ST-GOBAIN
15. FIRE EXTINGUISHER	ANSUL, KIDDE,
16. PUMPS	SALMSON, GRUNDFOSS, BELL & GOSSET, RITZ, PULLEN
17. SANITARY FIXTURES	LECICO, V&B, GROHE
18. HOT WATER STORAGE TANK	THERMOR, ARISTON
19. POLYETHYLENE WATER & TANKS	N.T.G.
20. AIR CONDITIONING	CARRIER, YORK, TRANE, HITACHI, DAIKIN

ITEM	MATERIAL
21. GRILLES AND DIFFUSERS	ANEMOSTAT, TROX, TITUS, FRANCE AIR, METALLAIRE, WATERLOO
22. SOUND ATTENUATORS FLEXIBLE DUCTS	FRANCE AIR, TROX, WOODS
23. FANS	SOLYVENT-VENTEC, WOODS OF CHOESTER, FRANCE AIR, GREENHECK
24. MEDICAL GASES	MEDAES
25. BOILERS ,BURNERS ,RADIATORS	CHAPPEE , DE-DIETRICH
26. KITCHEN EQUIPMENT	SOLARCO, VRESSO, EQUIP HOTEL

DIVISION 16

ELECTRICAL WORKS

DIVISION 16
ELECTRICAL WORKS
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Division 16**ELECTRICAL WORKS****GENERAL CONDITIONS AND REQUIREMENTS (16010)****A. Generalities**

The contractor must provide complete installations from the power supply terminals indicated on the drawings. The scope of work includes supply, installation of material and equipment as described in the specifications and/or shown on the drawings. Associated civil works including supporting structure, are also the responsibility of the Contractor.

B. General Conditions and Requirements

Work shall be carried out in accordance with the latest issue of the French regulations.

Equipment and material are to be manufactured in compliance with the relevant recommendations of the International Electro technical Commission (IEC) or approved equivalent standards.

Locations shown on the drawings indicate the approximate location of apparatus. Exact and final locations are to be coordinated with all other trades.

Work must be carried out in a neat and efficient manner in accordance with the specifications. Installations are to be complete ready for operation and fully coordinated with all other works.

Necessary items/accessories for operation of the systems are to be provided even if not mentioned in the specification/or shown on the drawings.

Wiring layout shown on drawings is to be used only as a guide. Electrical drawings must be checked against all other trades drawings.

C. General design conditions

Power will be delivered to the site by EDL at 380/220 V, 3 phases, 4 wires, 50 Hz. An earthing system should be provided.

Equipment shall be selected for continuous and trouble free service under climatic conditions of equipment location.

D. Submittals

The contractor is responsible to prepare 3 sets of shop drawings and ask for approval before any construction. These drawings are to show that the design concept is understood.

Documents relative to equipment to be supplied and installed must be submitted for approval. Therefore, no equipment may be installed before getting prior approval.

For approval, the contractor has to submit detailed manufacturer's specifications, original catalogue cuts and drawings of equipment and materials to be used.

The client reserves the right to operate operable defective equipment until its repair or replacement. Spare parts are to be supplied. These should cover the items recommended by the manufacturer for two years operation.

The contractor must guarantee the equipment/material installed for at least one year after the final hand-over. During this period, the contractor is to undertake to make good any defect without additional cost.

E. Site Tests

Acceptance tests should be carried in accordance with the regulations and standards. Equipment and labor for testing are to be provided by the contractor.

A visual inspection to check proper installation, connections and nameplate data must be carried on before testing.

Lighting and power circuits, motors, etc., must be subjected to an installation resistance test with a Megger of at least 1000 Volts operating voltage. Communications and security systems must also be subjected to a resistance test.

A continuity test to all major feeders and circuits must be done.

F. Manuals

Complete 2 sets of instruction manuals must be provided. These should cover operation, maintenance and spare parts list of all equipment and systems.

G. As-Built Drawings

Three complete sets of as-built drawings must be provided.

H. Training

The contractor must demonstrate to operating personnel the functions and operation of all equipment before handing over. The operating personnel must be trained to perform necessary adjustments to equipment, appliances and effect routine maintenance.

J. Contractor Responsibility

The Contractor shall be responsible of the work covered in this Division including the supply, transport, storage, installation, testing and delivering in good running conditions the electrical installation. The installation of all items shall be as specified and shown on drawings, catalogues.

K. Coordination of Work

The Contractor shall be responsible for coordinating the work of the Electrical installation, with that of other trades. He shall prevent interference's and conflicts and shall be the sole responsible for damages to work of other trades, already completed.

L. Guarantee

The Contractor shall guarantee his works for the duration of one year from the date of the completion certificate. He shall make good any defect, not due to ordinary wear and tear or improper use or care.

M. Payments

Payments shall be done on a monthly basis, according to the progress of the work.

PANELBOARDS (16116)

A. General Requirements

This section covers the supply and installation of main distribution board and distribution panelboards including all necessary fittings, cable termination accessories, supports and mounting frames.

All components are to comply with relevant IEC standards and mainly with IEC 439-1 for panelboards and with IEC 947 for circuit breakers and contactors.

Contractor is to submit for approval all detailed description of components supported by the original catalogue cuts. Technical data used for the selection and sizing of internal components such as busbars, earthing breakers, contactors, metering instruments, etc... are also to be submitted for approval.

In addition to the above, contractor to submit for approval prior to ordering equipment "Shop and Construction drawings" illustrating at least the details of panelboard (plan and elevation, built-in equipments, dimensions), installation details and clearances with the assigned room, single line diagram, internal wiring details, etc...

B. Main Distribution Panelboards

Contractor shall supply and install main distribution boards with all components and accessories as required and shown on the drawings.

Enclosure must be sized to fit breakers, indicated on the drawings and schedules.

Panelboards shall be minimum 600 V class, IP55, totally enclosed, factory assembled and tested, ready for installation. Construction must meet IEC requirements 529.

Cubicles must be of the interior type, floor mounted with provision in the base for fixing to a concrete plinth.

Frames are to be constructed from folded steel angles strengthened by horizontal and vertical folded channels and corner gaskets.

Frameworks are to be enclosed by electrozincated phosphated sheet stell of minimum thickness of 1.5 mm.

Boards shall be modular, each module shall have lifting eyes. When lifting eyes are bolted to the enclosure, suitable infills are to be provided so that the defined IP is not derated.

Compartment doors are to be fitted with gaskets so as to protect the interior against the ingress of dust and water when the door is closed. Compartment doors are to be rigid to prevent any distortion.

Hinges on compartment doors are to allow for the doors to be opened to greater than 90°.

The interior compartment mounting plates shall be constructed from a minimum of 2mm flat sheet steel and are to be rigidly fixed into the compartment.

Panel steelwork shall be protected against climatic conditions by degreasing the steelwork with rust inhibitor and applying two coats of primer and two top enamel finish top coats and epoxy powder baked.

The steel work paint finish shall be subjected to a corrosion resistance test at ambient temperature.

Busbar and busbar connections shall be capable of carrying continuously their rated normal current with a temperature rise taken into account in addition to withstanding the short circuit current for 1 second. Limit of temperature rise shall be based on a peak value not exceeding 45 degrees celsius.

Busbars and busbars connections shall be hard drawn, electrotinned, high conducting, hard copper running the complete length of the panel and shall be supported by synthetic bounded paper or synthetic bounded illuminated wood and shall be capable of safely withstand stresses and short circuit.

Busbars bends shall be carried out in a cold state with dedicated tools in order not to devalue the mechanical, thermal and dielectric properties of the busbars.

Minimum clearances for open indoor insulated busbars and busbar connections shall be 19mm between phase and earth and 25.4mm between phases.

Contractor must provide operation and maintenance manuals in addition to a fully detailed single line diagrams.

C. Components

C.1 Moulded Case Circuit Breakers

Circuit breakers are of the totally enclosed moulded case construction from an approved manufacturer and with front operated handle mechanism for manual operation in addition to automatic operator under overcurrent conditions.

Each pole is to have thermal bi-metallic inverse time-delay overcurrent element for overloads and instantaneous magnetic overcurrent trip element for operation under short circuit conditions.

Frame sizes are to be related to the minimum acceptable short circuit interrupting ratings. Trip current rating indicates nominal rating at which thermal overload element operates.

Moulded case circuit breakers shall be in accordance with IEC 947-2 recommendations.

A total discrimination should be provided between moulded case circuit breakers in order to make the circuit breaker immediately upstream only trips from a fault.

C.2 Miniature Circuit Breaker (MCB)

MCB to be of the thermal magnetic non-adjustable type with a minimum short circuit breaking capacity of 5KA. MCB are to operate under overload and short circuit conditions and made from high quality moulded insulating material.

Auxiliaries are to be provided as required by the design.

A total discrimination should be provided between moulded case circuit breakers and miniature circuit breakers.

C.3 Automatic Transfer Switch (ATS)

ATS to comprise 2 contactors and necessary controls for automatic transfer of power supply from normal source (EDL) to emergency source (generator) such as voltage sensing control relay, time delay relays, auxiliary switches, mechanical interlock, indicating lamps, etc... as necessary for the required operation of the system.

Contactors are to comply with IEC 947 and be 3 phase, 4 pole magnetic type (AC3 duty).

Normally open and close contacts are to be provided on each contractor as necessary.

Manual command shall be available.

C.4 Metering Instruments

Instruments are to be housed in enamelled square metal cases for flush installation. Accuracy of instruments is to be within 2%.

Voltmeters are to be of the moving iron type with zero adjuster, 90 degree angle, range 1.25 times nominal system voltage. (size 76 cm x 76 cm).

Voltmeter selector switch to be of the 7 position rotary type.

Ammeters are to be also of the moving iron type with centre zero adjuster.

90 degree angle and 2 times nominal system amperage. (size 76cm x 76cm).

Current transformers are to be of the indoor dry type with a rated secondary current of 5A.

C.5 Miscellaneous

Wiring to be neatly arranged on terminal blocks with suitable numbering. Control wires are to be copper, PVC insulated, 600V grade.

Anti-condensation heaters with disconnect switches and pilot lamps are to be provided in the switchboard controlled by a thermostat.

Power and control diagrams are to be provided and suitably located within the cubicles.

D. Surface Mounted Lighting and Power Panelboard

Panelboard cabinet shall be of the general purpose type made from hot galvanized sheet steel (15 mm) IP42 or IP55 depending on its location. Joints are to be welded and reinforced where necessary. Gutter spaces are to be at least 100 mm on all sides.

The front is to be of the cold rolled sheet steel of not less than 2.5 mm. Doors shall be provided with concealed hinges and flush lock. A coat of zinc chromate primer and one coat grey enamel finish are to be applied. Directories are to be provided on doors and typed to identify panelboards and indicate clearly circuit number and description of associated branch circuit.

Interior of panelboard consists of branch circuit breakers mounted on buses or on rails. Buses must be 98% pure electrolytic copper based on total temperature rise of 30 deg. C over ambient of 50 deg. C. Aluminum is not to be used for interior panelboard parts.

Buses are to be supported rigidly and mounted on moulded insulators. These should carry the maximum short-circuit duty of main protective device, which is at least the maximum short circuit at point of application, without showing signs of deterioration.

Screws and bolts used for making copper connections are to have lock washers.

Panelboards are to have ground earthing connector or bar welded to cabinet.

E. Panelboards supplied by specialist contactors

The panelboards listed hereafter will be supplied by mechanical or other specialist contactors.

Panelboards will be surface mounted, made from sheet steel (10/10 minimum); IP55. The breaking capacity for the breakers of these panelboards superior or equal 10KA.

F. Installation and tests

Main switchboards are to be installed on concrete bases, levelled. Concrete foundations are to be constructed in accordance with equipment manufacturer drawings. Any painted surface damaged during handling and installation is to be rectified before commissioning.

Main switchboard is to be tested on site for its completeness, component ratings, types, sizes and connections. Main and control circuits are to be checked for insulation. All tests required by the standards are to be carried on to the satisfaction of the Engineer.

G. Submittals

The following documents (but not limited to) are to be provided :

Manufacturer's catalogue cuts (for panelboards, circuit breakers characteristics, dimensions, etc.)

Shop drawings showing exact composition of each panelboard (busbar rating, frame and trip ratings of all circuit breakers, etc.) in addition to the installation details.

WIRES, CABLES AND FEEDERS (16117)

A. General Requirements

Unless otherwise indicated, wires, cables and feeders are to have copper conductors and manufactured to IEC502. Cable and wire conductors are to be stranded for sections 4mm² and above.

Current carrying capacities of conductors have been determined in accordance with the regulations for the specified type of installation and expected conditions of installation.

Installation of each conductor is to be color coded. Contractor has to maintain coding throughout the installation.

Branch circuit work originating from lighting panelboards is to be arranged as shown on the drawings. Loads on phases of panelboard feeder are to be balanced.

Final circuit wiring is to be run inside conduits. DC wiring is to be run in separate conduits from AC wiring.

Feeders to panelboards and isolating switches are to be either single conductor wires pulled inside heavy gauge rigid PVC conduits or multi-core cables run on cable trays under ceiling or cable ladders in shafts or in duct bank in ground. Cables buried directly in the ground are to be armoured.

Low current systems cables are to run inside heavy gauge rigid PVC conduits.

B. Technical Specifications

Single conductor wires and cables for wiring in conduits are to have high conductivity, electrolytic annealed copper conductors and insulated with PVC.

PVC insulated cables are to have high conductivity, electrolytic annealed copper conductors insulated with PVC flame retardant suitable for conductor temperature exceeding 65 deg.C, bedded with suitable filler and sheathed with PVC.

Bare grounding cable is to be single conductor, stranded for sections above 4 mm², bare copper and suitable for use as ground conductor.

Two pair telephone cables for wiring to each telephone outlet are to be PVC insulated and PVC sheathed. Additional ground wire is to be provided in each cable.

Control cables are of the multicore type, PVC insulated and sheathed rated 0.6/1KV. Insulated conductors are numbered. Diameter of conductors is to be 1.5mm².

Fire resistant control cables are to be 0.6/1KV fire resistant to IEC 331, halogen free.

C. Installation of cables

Cables are to be installed in PVC rigid conduit or duct outdoors.

Fire resistant conductor wires are to be installed in steel conduits.

Bunching of wires in conduits is not to exceed filling factors permitted by the regulations.

Cables terminating in outlet boxes are to be left with at least 250 mm extra length for terminations.

Single cables are to be fixed directly to walls or ceilings by metallic clips. Where three or more cables are run in parallel, they are to be fixed on galvanized steel perforated trays.

D. Submittals

The following data (but not limited to) are to be provided :

- Manufacturer's catalogue cuts (standards, construction, current carrying capacities, derating factors, etc.).
- Shop drawings showing exact routing of feeders, sub-feeders, etc.; details of supports; number and size of conductors in conduits; etc.

CONDUITS AND WIREWAYS (16118)

A. General Requirements

Unless otherwise indicated, all lighting and power circuits, communications and low current systems wiring are to be drawn inside conduits or wireways up to the various electric power consuming equipment.

Separate conduits and wireways are to be used for normal lighting and power circuits, communication and other low current systems wiring.

Junction and pull boxes of ample capacity are to be provided as required. Boxes are to remain permanently accessible.

Sizes of conduits and wireways not shown on the drawings are to be selected in accordance with the regulations and in relation to the number and size of conductors as shown in the table below:

**Number of Conductors Relating To
Exterior Diameters Of Conduits**

A	B	C	D
	2 2 3	2 2 3	2 25 32
0	5 2	0 5 2	0
1.5	7 7 7	7 7 7	6 7 7
2.5	7 7 7	6 7 7	4 7 7
4	5 7 7	4 7 7	3 6 7
6	4 7 7	3 6 7	-- 4 7
			-
10	-- 4 7	-- 3 6	-- --- 4
			-

A: Section of Conductors (mm²)

B: Straight Run

C: Run With One Bend

D: Run With Two Bends

Conduits and wire ways are to be designed, constructed and installed to provide safe and reliable installation protection.

Minimum size of conduit for Power Installations is to be 20mm (external diameter), unless otherwise indicated.

Minimum size of conduit for Low Current Installations is to be 25mm (external diameter), unless otherwise indicated.

Metallic cable trays are to be used for main power feeders.

Steel conduits are to be used for alarm and voice control circuits.

Rigid heavy gauge UPVC flame retardant conduits are to be used for all power, lighting and low current surface mounted electrical installations indoor and in ground electrical installations outdoor.

Flexible conduit of same material as corresponding conduit is to be used for connection to motors and to fixtures installed in false ceilings.

Cable and conduit fixing devices are to be metallic.

B. Rigid Heavy Gauge PVC Conduit

Material is to be of rigid unplasticized PVC with high impact and high temperature resistance, flame retardant.

Fittings are to be generally unbreakable, non-inflammable, self extinguishing plastic.

Conduits, boxes and accessories are to be assembled by glueing using appropriated connectors.

C. Flexible PVC conduit

Material to be ribbed on circumference, flame retardant PVC, high impact resistance, high temperature.

D. Steel conduits and fittings

Where the installation of steel conduits is specified they shall be heavy gauge, welded and galvanised and threaded at both ends to BS 4568 Part 1 and BS31 class B.

All conduit fittings shall be of similar materials and compatible to the particular conduit being used.

E. Cable Trays

Cable trays are to be installed as a complete system with all relevant accessories.

Material is to be from hot dip galvanized heavy gauge perforated sheet steel (thickness greater or equal to 1.5 mm) with corrosion resistant coating. Size of tray is to be determined by number and sizes of cables in accordance with the regulations.

Additional protection of fire-proof barriers should be provided where cable trays pass through walls and partitions. Cable trays are to be earthed at maximum spacing of 30m.

F. Workmanship

Conduits are not to cross pipe shafts, vents or openings.

Conduits must be installed at least 100 mm clear of and above pipes of other non-electrical services. An expansion fitting is to be provided in each conduit services run crossing an expansion joint in the structure.

Conduits are to be properly capped until wiring conductors are drawn in.

PVC rigid conduit runs are not contain more than the equivalent of two quarter bends.

Flexible conduits are to permit bending of feeder cables without damaging the conductor or the insulation.

Spacing of clamps or clips for supporting PVC conduits is not to be greater than :

<i>Conduit size (mm)</i>	<i>Maximum spacing of supports (m)</i>
20	0.60
25 - 50	0.75
63 - 75	0.90

Junction boxes near ceilings are to be installed to act as pull boxes.

Sleeves for cables must be filled with a fire retardant compound to prevent fire spread from one compartment to another.

G. Submittals

The following data (but not limited to) are to be provided :

- Manufacturer's catalogue cuts
- Shop drawings showing the exact routing of conduits, exact location of flexible conduits, etc...

PROTECTION SYSTEMS (16119)

A. Surge Arresters

Surge arrestors installed on the main feeders will be of type 0 and those installed in SDBs will be of type 1 as detailed here under.

A.1 Type 0

Type 0 surge arrester is of the lightning current arrester type with the following characteristics:

- Peak current: 50 kA (10/350 μ s) and up to 100 kA in multipole.
- Response time: less than 100 ns.
- Insulation resistance: > 1000 M Ω .
- Voltage protection level (1.2/50 μ s): less than 4 kV.

The surge arrester should include also a protection for neutral line as we are working in a TT system that support a lightning impulse current of 100 kA (10/350 μ s) and other caractesistics equal to those listed above.

A.2 Type 1

Type 1 surge arrester is of the over voltage arrester type with the following characteristics:

- Nominal discharge current: 15 kA (8/20 μ s).
- Maximum discharge current: 40 kA (8/20 μ s).
- Response time: less than 25 ns.
- Voltage protection level: less than 1 kV.

A.3 Class I Four pole Modular protective devices:

Maximum discharge current 35KA per pole, wave 10/350 μ s.

Residual voltage less than 4KV.

Response time less than 100ns.

Self protected via built-in thermal protection.

Supplied with associated disconnector.

To be installed: at the standby power generator and at supply side of ATS's

A.4 Two pole Modular protective devices:

Maximum discharge current 15KA per pole, wave 8/20 μ s.

Residual voltage less than 650V.

Response time 25ns

Self protected via built-in thermal protection.

Supplied with associated disconnector.

Two pole devices are to be installed close to each low current system cables.

The device is to be provided with enclosure.

B. Approved Manufacturers

B.1 DEHN

B.2 J PROPSTER

B.3 KRONE

B.4 Or other equal and approved

LIGHTING FIXTURES (16331)

A. General requirements

Unless otherwise specified, fixtures are to be manufacturer's standard series.

Exact position of fixtures must be coordinated with the reflected ceiling plan.

Fixtures are to be fabricated, assembled and wired entirely at the factory. Site work is to be restricted to reassembling parts dismantled at the factory for packing and transportation.

Sheet steel for reflectors should not be less than 0.8 mm thick.

Aluminum sheet for reflectors should not be less than 1.0 mm thick.

Light reflecting surfaces are to be finished with white baked enamel paint having a reflection factor not less than 80%.

Finish is to withstand 72 hours exposure to an ultra-violet RS lamp placed 100 mm from surface.

Wiring to be not less than 1mm², insulated for 240 V supply. Wiring is to be terminated on screw type insulated, terminal blocks.

Recessed fixtures to be constructed to fit into suspended ceiling.

Fixtures are to be provided complete including control gears.

Fixtures are to be as specified and shown on the drawings.

Recessed fixtures in suspended ceilings are to be coordinated with exact dimensions of ceiling tiles.

Fluorescent fixtures

With built-in ballast. Single or two lamp ballasts are to be used in any one fixture. Two lamp ballasts are to be lead-lag series type.

Each ballast is to have an external fuse and fuse holder rated in accordance with manufacturer's instruction. The ballast is to be of high power factor (greater or equal to 0.85).

All fixtures are to have two cable entry holes.

B. Lighting fixtures description

ALL lighting fixtures shall be as described in the legend and/or shown in the bill of quantities

C. Standard tubular fluorescent lamps

Normal start, bi-pin, rated as described on the drawings. Color of light is to be warm white. Guaranteed rated life is to be above 8000 hours and luminous output above :

- 1350 lumens for 18 W lamps
- 2850 lumens for 36 W lamps
- 4600 lumens for 58 W lamps

D. PL fluorescent lamps

Compact, with special bi-pin socket, rated as described on the drawings. Color of light is to be warm white. Guaranteed rated life is to be above 5000 hours and luminous output above the following :

- 600 lumens for 9 W lamps
- 1200 lumens for 18 W lamps
- 1450 lumens for 22 W lamps

E. Workmanship

Fixtures are to be installed aligned, leveled and at uniform heights within one room or area. Fixtures are to be supported with hangers to support weight of fixture.

F. Submittals

The following data (but not limited to) are to be provided :

- Manufacturer's catalogue cuts.
- Installation details.
- Photometric data, etc...

WIRING DEVICES (16441)

A. General Requirements

Supply and install electrical fittings including switches, sockets, etc., together with matching outlet boxes and plates and connect to power supply as shown on the drawings.

All devices are to be standard manufactured items, uniform and modular.

A1 Outlet boxes

Boxes and covers are to be made of heavy gauge pressure moulded plastic and to be manufactured for required application. Boxes to have brass threads for cover screws fixing. Provision for securely terminating conduits are to be provided.

Plastic cover plates are to be of heavy gauge, break resistant, made from pressure moulded plastic.

Surface or recessed boxes are to be suitable for the type of related conduit system. Sizes of boxes are to be suitable for application with switches, sockets, etc,...

A2 Switches

Switches are to be of the quick-make, quick-break type with silver alloy contacts in moulded base. Types are as shown/described on the drawings.

Single pole switches are to switch the phase wire. Switches are to be mounted with long dimensions vertical and operating handle up when in the "OFF" position.

Switches in blind areas, shall be equipped with indicating lamp.

A3 Socket outlets

Each single-phase socket-outlet and plug shall have 2 terminals and one earthing contact. They shall be rated for 10/16 Amp. and 20 Amp. - 250 V. Safety shutters shall cover pin holes to prevent accidental contact.

Fixing the socket and cover plate to the box shall be done with stainless steel or chromium plated screws. Hook fixings are forbidden.

Socket outlets shall be flush or surface mounted according to the type of the installation. Flush mounted socket outlets shall be installed in their boxes with screws.

Floor sockets shall be fixed in flush outlet boxes or concealed screws not chrome plates.

Socket-outlets and plugs intended for the same duty in different locations shall be installed at the same heights.

Socket outlets fed from UPS shall be standard Red colored.

The exact locations of socket-outlets and plugs shall be determined according to the construction details of the building. These locations shall be submitted for the Engineer's approval.

A4 Isolating switches

Used to interrupt loads, rated as shown on drawings, 250 V AC with tumbler operating handle to give positive indication of "On/Off" position of contacts.

The contractor shall provide circuit and motor disconnect switches in types, sizes, duties, features ratings as indicated, and where required by the Regulations/Code applicable. For motor and motor starter disconnects, the contractor shall provide units with horsepower ratings suitable to the loads.

Isolating switches should be two or four poles as indicated on drawings rated to the nominal current of the circuit, as indicated on the drawings, with rapid make and break movements to allow on load circuit breaking in accordance with IEC 408, with external operating handle mechanically interlocked to prevent opening door unless switch is in open position. Switch disconnector is to have provision for by-passing interlock. Position of handle is to be positive and clearly indicated on cover. Utilization category 22 for heating and lighting loads and category 23 for motor circuits. The isolating switch should be installed close to the equipment in an IP65 built-in enclosure.

The isolating switch shall be non-fusible, air-break switch disconnector, single throw, safety type, housed in separate metallic enclosure with arc quenching devices on each pole.

The enclosure shall be sheet steel for indoor use IP 41, and weather-proof type cast-metal or sheet steel for outdoor installations IP 65, unless otherwise required or shown on the Drawings. Locking of operating handle is to be possible in open and closed positions

A5 Trunking unit

The trunking unit suitable for fixing directly to the wall is made of extruded anodised aluminium painted in polyurethane powder and resistant to cleaning agents.

The trunking shall be a twintrunk system in which the upper unit used for electrical installations is divided in two compartments with partition to separate high and low current systems and the lower unit used for medical gases is screened off by an integral partition. Both upper and lower units have separate flush front covers.

The trunking unit can be fitted with bedhead unit, power and telephone sockets, all modular wiring devices, medical gases sockets and up to 3 tubes of medical gases 10/12mm.

The trunking unit should be factory assembled and prewired with two prewired terminal blocks at the end of the trunking unit easily accessible from the front (for high and low current).

The trunking unit should be factory fitted according to the position of the bed and the length of the room.

It shall be supplied with all necessary accessories like end caps, different types of angles, cable clips, mounting boxes, earthing clamps and terminals, earthing terminal and wire for bonding the front cover.

A6 Bedhead unit

The bedhead unit suitable for rapid mounting on the trunking unit is made of extruded anodised aluminum painted in polyurethane powder and resistant to cleaning agents.

The bedhead unit shall be factory fitted, assembled and prewired according to the position of the bed and the length of the room.

It shall be fitted for each bed with :

- Indirect compensated fluorescent lighting 2x36w on aluminum reflecting support with polycarbonate diffuser, with two way switch controlled from BHU and room entrance door.
- Direct compensated fluorescent lighting for reading 1x18w on aluminum reflecting support with polycarbonate diffuser, controlled only from the BHU.
- Two power socket outlets 2P+E, 16A, one from each side of the bed.
- One 24V multipin socket for hand-held remote control unit with transformer and relays.
- One hand-held 24V remote control unit supplied with 2 meters lead and plug, equipped with one push-button for reading lighting and one push-button for patient call..Emergency nurse call point shall be also provided
- One telephone/DATA socket shall be installed in the bedhead unit, in each patient bedroom.
- Medical gas outlet, as required and shown in the mechanical medical gases drawings.

B. Installation and Tests

Locations shown on drawings are approximate. Exact locations are to be shown on shop drawings. Switches are to be located at strike sides of doors and mounted at 120cm from finished floor levels. Socket outlets are to be mounted at 30cm from finished floor level.

All fittings are to be visually inspected for fixing, workmanship and operation to the satisfaction of the Engineer.

C. Submittals

The following data (but not limited to) are to be provided :

- Manufacturer's catalogue cut with complete detailed literature specifications, overall dimensions, etc...
- Shop and construction drawings showing exact location of each outlet box, installation details, wiring diagrams, etc...
- Samples along with material approval requests.

DATA AND TELEPHONE SYSTEM (16741)**A. General**

The data and telephone system shall consist of complete installation of all conduits, conduit fittings, junction boxes, pull boxes, outlet boxes, data and telephone cables, data socket outlets, circuit wiring, wiring connectors and all work relating to the data and telephone installation in accordance with the drawings and as directed by the Engineer.

Outlet faceplates shall be integral with other types of outlet faceplates.

Suitable distributing data and telephone terminal and junction boxes with suitable connectors shall be provided as required on the drawings.

Numbered tags corresponding to the respective branches shall identify terminals.

B. Execution

A clearance of at least 20 cm must be respected between the low current cables and the power cables in all the installation.

Each data cable should be one piece from each outlet to the corresponding network cabinet as shown on drawings.

All 4 pairs of each TP cable shall be terminated on a single port. The splitting of cable pairs between different jacks is not permitted. Terminating resistors required in certain applications shall be placed externally to the outlets.

Terminating cable pairs (Category 6) shall have a maximum of 13 mm (1/2 inch) of cable untwisted before termination.

One telephone cable, per network cabinet, with number of pairs as indicated on drawings will be used for the connection of the network cabinet to the MDF. Main telephone feeder will run inside PVC duct and on cable trays as shown on drawings.

All telephone and data cables will be installed on the same side inside the shaft and will be clearly labeled to indicate the type and destination on each floor level.

During the actual installation, bend radius on 4-pair cable shall not exceed eight times the outside diameter of the cable and ten times for multi-pair cable. This shall be done unless this violates manufacturer specifications.

In the telecommunications room/closet where cable trays or cable racking are used, the contractor shall provide appropriate means of cable management such as reusable color-coded hook and loop cable managers (ties) to create a neat appearance and practical installation.

In telecommunications room/closets a minimum of 3 m of slack should be left for all cable types. This slack must be neatly managed on trays or other support types.

Tie wraps shall be used at appropriate intervals to secure cable and to provide strain relief at termination points. These wraps shall not be over tightened to the point of deforming or crimping the cable sheath.

Hook and loop cable managers should be used in the closet where reconfiguration of cables and terminations may be frequent.

C. Telephone cables

Telephone cables shall be multi-pair cables with high conductivity standard annealed copper of 0.6 mm, insulated with one layer fully colored solid polyethylene. The cable core interstices are filled with suitable compound to avoid longitudinal water penetration inside the cable. The cable core should be protected with one or more tapes helically or longitudinally laid with an overlap. The outer sheath will be polyethylene or PVC.

Conductors should be twisted by pairs and grouped by sub-units of 10 pairs. Spare pairs should be located within the sub-unit. The outer shield will be marked to show the manufacturer's identification, the number of pairs, conductor diameter and a sequentially numbered length marking at each meter interval.

Telephone cable sizes are to be selected to fulfill all the wiring relevant to existing telephone lines plus the spare requirements.

Telephone cable running between the MDF and network cabinets should be connected to IDC connectors at the MDF side and to patch panels on cabinets side with 1 RJ45 per telephone pair.

The main telephone cable connected to the MDF shall be protected from lightning at both sides (from the PABX and MDF sides).

Telephone cables are to comply, at least, with the following specifications:

- Maximum conductance DC resistance: 130 Ω /Km (at 20°C)
- Maximum attenuation: 1.2 dB/Km (at 800 Hz)
- Maximum mutual capacitance: 70 nF/Km
- Voltage rating: 150 V
- Minimum insulation resistance: 5000 M Ω .Km at 200 V DC

D. Data cables

Computer network conduits will be twisted unshielded 4 pairs category 6 (UTP 4P), linking each point individually to the patch panel as shown on drawings. These cables shall conform to ANSI/TIA/EIA-568-A Commercial Building Telecommunications Cabling Standard and ISO/IEC 11801 (International) Generic Cabling for Customer Premises standard (latest amendment and including all applicable addenda). Pairs within a cable shall not be split and all pairs must be terminated

E. Outlets

The outlets should be manufactured by Alcatel, Siemon, Krone or approved equal. The selected type should provide maximum flexibility in supporting TP, fiber, and coax while maintaining performance in order to meet the changing requirements that are likely to occur throughout the life of the system. All these outlets should fit within the same faceplates used for all sockets, switches...

Manufacturer shall warrant all modular outlets used. Terminated conductor ends shall be properly trimmed to assure a minimum clearance of 0.25 in. between the conductors of adjacent modules. The outlets shall not be responsible for creating "resonance" on short cable runs as described in the Field Testing TSB 67. This problem is related to return loss and/or the balance of the link and can cause transmission errors. Outlets shall be available in several colors.

F. Grounding

Proper grounding and bonding is essential and reference shall be made to proper codes and standards. Grounding of metal shield shall be made with 16 mm² copper wire. Backbone systems must comply with all applicable National, Regional, or Local building and electrical codes.

Each distribution rack shall be connected to the ground bus in accordance with the applicable code requirements as per EIA/TIA 607.

Backbone cabling utilizing a shield shall be bonded at each sheath opening.

G. Fixing, Labeling and marking accessories

Fixing accessories shall include cable ties, clamp ties, push mounted ties, marker ties. All outlets, patch panels, cross-connects, cabinets... shall be labeled using a mechanically imprinted label similar to Brady or a system as proposed by the contractor and agreed by the Engineer. Regardless of the numbering scheme, every cable has the same permanent identifier at both ends. Each label shall indicate, according to an approved labeling designations, the number of the cable concerned, where it is coming from and where it is going to.

Horizontal cables shall be labeled at each end. The cable or its label shall be marked with its identifier. A unique identifier shall be marked on each faceplate to identify it as connecting hardware. Each port in the faceplate shall be labeled with its identifier.

H. Cable laying

Data and telephone cables shall run in dedicated raceways apart from those where power cables are laid as shown on drawings.

Before the start of cable works, the site shall be properly checked in order to ensure that the raceways, whatsoever, are clean and dry. Cables shall be carefully unreeled from drums, and pulled-in/laid on raceways according to the approved shop drawings and work procedure. Specialized rolls and tools shall be used for main cable works so as the cables shall not be dragged on ground or surfaces. Cables are to run concealed above cable trays, and through embedded pipes. After the network is satisfactorily completed and tested, cables shall be tied to cable trays and labeled as necessary. For any cable, the maximum distance between two successive ties shall not exceed five meters except for vertical riser cables where the maximum distance shall be two meters. Cables shall be labeled at every terminal location, every bent, before every distribution unit and at every fan-out.

Moreover, vertical main cables along the riser, shall be labeled twice at each floor. Cables shall be terminated at the distribution units where they shall be held, fanned out properly, and wired to the terminal blocks or patch panels. Wires shall be tied into groups, in accordance with the order of pairs as per color code, and corresponding to the relevant connection modules (or strips). Wiring to the terminal blocks in MDF and network cabinets shall be performed by standard IDC connection tools.

NURSE CALL SYSTEM (16750)**A. General requirements****A1 Work included**

Work comprises supply and installation of a complete microprocessor controlled Nurse call system as described herein and shown on the drawings.

The system shall include :

- Main console units with all additional boards, DC regulated power supply and accessories necessary for the good operation of the system.
- All room interfaces and system interfaces needed and DC regulated power supply.
- All system devices needed like call units, Door units, Corridor bulkhead lights, etc, ...

Works are to include supply and installation of mounting Boxes, Cables, Conduits, Pull and junction boxes, Connectors, Raceways and all other accessories necessary for a complete function of the system.

The contractor shall coordinate the electrical installations of the nurse call system with other trades where necessary.

The system shall be completely tested to assure that all components, stations and other accessories are connected and operational.

All items of Nurse call system shall be manufactured by a single reputable manufacturer.

A2 Submittals

Provide three (3) copies of submittals within 30 days from contract award.

Layout of equipment, Typical wiring diagrams.

- Bill Of Materials
- Samples: Provide one sample of all field devices.
- Installation details: Provide one copy of installation instruction sheet for all system components.
- Specifications: Provide one copy of specification sheet for all system component.
- Certificates: Provide one copy of all required certificates and approvals as per local civil defense regulations.

B. Products

B1 System description

The nurse call system shall provide efficient and reliable signaling between patients and staff. The system shall be display based.

The system shall include a main console unit in the nurse post room, nurse door unit at the entrance of each patient room, a patient call unit at each one or two beds and at bathrooms and a corridor bulkhead light over the door of each patient room.

The system shall use the necessary interfaces in order to minimize wiring to a single cable carrying all necessary information.

The system shall provide interfacing to radio paging.

B2 System operation

The patient calls by pressing the push button at the hand-hold remote control unit of the bedhead or trunking unit.

The red indicator room of the door unit and the red bulkhead light above the door of the room flashes slowly and the audible signal sounds.

The Nurse acknowledges receipt of the call by pressing the mute button, the red indicator stops flashing and becomes steady and the audible signal stops.

In the room the red room indicator stops flashing and become steady and the red bulkhead light above the door goes to steady.

The nurse cancel the call by pressing the push button on the door unit as she comes in, the indicators go out in the room, in the corridor and on the console. If the patient calls by pulling the cord operated push button in the bathroom then the red bathroom indicator, the red and white indicator room of the door unit and the read bulkhead light above the door of the room flash rapidly. On the main console unit the room numbers appears, the red indicator flashes rapidly and the audible signal emits a rapid intermittend sound. The nurse goes to the room and cancels the emergency call by pressing the door unit push-Button.

B3 System units

Main console unit

The main console unit shall be of desk-top type, resistant to cleaning agents used in hospitals.

It includes:

- Numeric display for showing room numbers in order of receiving calls and priority.
- Indicator lights, call mute and attendance indicator call signal buzzer
- Alarms triggered in the event of a power cut, data saved in memory.

Door unit

Door unit shall consists of a red indicator and a white indicator supplied and a call cancel button.

Door unit are to be supplied with a flush mounting box, metal support frame for server mounting and a white plate.

Bathroom call unit

Bathroom call unit consists of a push-button with pull cord mechanism and 24V red indicator lamp supplied with a flush mounting box, metal support frame for server mounting and a white plate.

Corridor bulkhead light above doors corridor bulkhead light consists of two triangular bulkhead light one with red diffuser and the other with white diffuser, 24 Volts lamps and supplied with bulkhead base, metal support frame for screw mounting and a white plate.

Patient call unit

The patient call unit shall be supplied within the bedhead or trunking unit.

B4 Installation

Cables should be selected and installed in accordance with manufacturer's specifications.

Cables are to run through heavy gauge rigid PVC conduits maintaining a minimum of 30 cm separation from any disturbance source as lighting fixtures, power cables HVAC equipments, ...

FIRE ALARM SYSTEM (16771)**A. General requirements**

Work included consists of the following :

- Automatic and manual detectors
- Alarm Devices.
- Interface and control modules
- Isolator modules
- Complete wiring system including conduits, fixing, accessories, etc...

Fire alarm system to be in accordance with the local fire protection Regulations and in compliance with International Standards.

Contractor to submit complete technical data for approval including codes, standards, manufacturer's original catalogue and specifications, circuit description, etc..

Test certificates, at the factory, are to be submitted to the Engineer immediately after obtaining product approval and before placing final order.

Contractor to submit shop and construction drawings for approval including at least the detailed system diagram, the exact composition of cabinets, exact routing

and layout of cables, etc...

B. System general description

Fire alarm system is to be an independent self-contained, audibly and visually supervised, analogue addressable, pre-signal system.

C. System components**C1 Manual Stations**

Manual stations shall be installed in correspondence of all escape routings, as shown on the drawings. Stations shall be of rugged die cast construction for surface mounting. For durability, plastic stations will not be acceptable. Stations shall be of the break-glass type, and must be opened to be reset. Closing the box after opening it shall automatically perform the reset function. It shall be possible, for testing purposes, to initiate an alarm without breaking the glass. Stations shall report an individual alarm to the FAP through the addressable loop. Stations shall be of the pre-signal type with a general alarm keyswitch and shall report both individual pre-alarm and alarm signals to the FAP through the addressable loop. Stations shall be equipped with 1 NC + NO contact. All stations shall be furnished with a spare glass rod.

Short circuit fault isolation to be provided.

Mounting to be 1.4m from Finish Floor Level.

C2 Optical Smoke Detector

The Photoelectric type detector shall be a plug-in unit which mounts to a twist-lock base, two wire operation and shall be UL listed.

The detectors shall be of the solid state photoelectric type and shall contain no radioactive material. They will use a pulsed infrared LED light source and be sealed against rear air flow entry.

Removal of detector head is to cause trouble alarm at the fire alarm panel. Detector is to be set to detect smoke regardless the type of fire combustible material, temperature and velocity of smoke, etc...

Detector is to have automatic supply voltage regulation, reverse voltage protection, etc...

The detector shall fit into a base that is common with both the heat detector and ionization type detector and shall be compatible with other addressable detectors and addressable manual stations, on the same circuit.

The detector is also to have a LED indicator flashing under normal operation and steady lit when detection is actuated. The reset is done from the fire alarm panel. The detector is to have at least the following characteristics :

- Normal operating voltage 24 V DC
- Alarm current 5 mA
- Ambient temperature 0°C to + 60°C
- Relative humidity 10% to 90%

There shall be no limit to the number of detectors which may be activated or "in alarm" simultaneously.

C3 Fixed Temperature Heat Detector

Detector is to have plug-in, twist-lock base, sealed against dust and moisture, two wire operation, and shall be UL listed.

A sensor monitors the ambient temperature and reacts at a fast rapid increase in temperature.

Removal of detector head is to cause trouble alarm at control panel.

Detector is to operate at 24 V DC. Also it must have an automatic supply voltage regulation, reverse voltage protection, etc.

The detector shall fit into a base that is common with both the heat detector and ionization type detector and shall be compatible with other addressable detectors and addressable manual stations, on the same circuit.

The detector is supplied with a LED indicator flashing under normal operation and steady lit when detector is activated. Reset is done from the fire alarm panel.

C4 Alarm Bell and Buzzer

Bells shall be polarized and shall be operated by 24 VDC. Each bell assembly shall include separate wire leads for in/out wiring for each leg of the associated signal circuit. Tapping of signal device conductors to signal circuit conductors shall NOT be accepted. Bells shall be vibrating type. Bells shall be finished in baked-on red enamel paint and be UL listed for fire alarm use. Bells shall be suitable for surface mounting and be suitable for use within combination audio/visual units.

Sound pressure level shall be selected to diffuse alarm only in the staff and nurse zone.

Strobes are to produce a minimum of 75 candela and operate at 20 to 24V. Unit to be compatible with DC supervision of alarm lines. Unit is to have red fire lettering and flash approximately one or two times per second. Light is to comprise of xenon slashtube and is to be entirely solid-state. Units are to be capable of either ceiling or wall mounting. lens to be lexan of pyramidal shape.

C7 Electro-Magnetic door holder

Door holders to be of the wall type with low power consumption. Upon signal transmission from the control panel, door holders are to release the smoke exhaust trap to an open position. Magnetic door holders shall have an approximate holding force of 16kg. The door portion shall have a stainless steel pivotal mounted armature with shock absorbing nylon bearing. Unit shall be capable of being either surface, flush, semi-flush or floor mounted as required. Doors holders shall be UL listed for their intended purpose.

Power supply to be 24VDC supplied from the fire alarm panel.

C8 Output Devices

The control circuit shall provide a conventional output for a Relay Control Module (RCM).

An open-circuit fault shall be annunciated at the FAP.

The RCM shall comprise the necessary relays (24DC, SPDT or DPDT) and shall provide power and control to command the shutdown of fans (FCU, Ventilation fans), activation of Fire Fighting Pumps, activation of suppression Fans, etc...

C9 Isolator Module

One Isolator module shall be provided at least by floor. If a short circuit occurs, the isolator module shall automatically disconnect the loop, limiting the number of inoperative detectors. When the fault condition is corrected, the isolator module shall automatically reconnect the isolated section.

C10 Wiring

Initiated devices cables are to be shielded twisted pair cables, halogen free with a flame retardant sheet.

Conductors are to be tinned annealed copper of minimum diameter size 0,6mm.

Bells and controlled circuits are to be 0,6/1KV fire resistant conductor wires to IEC331, halogen free. Conductors are to be tinned annealed copper of minimum 1.5mm².

D. Submittals

Provide six (6) copies of submittals within 30 days from contract award.

- Drawings: Riser diagrams, Layout of equipment, Typical wiring diagrams, Talk paths diagram, Annunciation diagram, Sequence of operation diagram.
- Bill Of Materials
- Samples: Provide one sample of all field devices
- Installation details: Provide one copy of installation instruction sheet for all system components
- Specifications: Provide one copy of specification sheet for all system component
- Certificates: Provide one copy of all required certificates and approvals as per local civil defense regulations

E. Installation

E1 General

The control system contractor shall be responsible for all electrical installation required for a fully functional control system, including all necessary wiring, installation materials, and accessories not shown on the electrical plans or required by the electrical specifications.

E2 Installation

All field devices shall be placed in accordance with the contract drawings, whichever is more demanding.

All system components shall be installed and mounted in accordance to the manufacturer's recommendations per Engineer's approval.

Separate cables shall be installed for the 24Vdc and the 240Vac functions. No common cable employing mixed voltages on different conductors shall be allowed.

E3 Wiring

All wiring shall be properly supported and run in a neat and workmanlike manner. All wiring and tubing exposed and in equipment rooms shall run parallel to or at right angles to the building structure. All piping and wiring within enclosures shall be neatly bundled and anchored to prevent obstruction to devices and terminals.

All wiring for detection circuits shall run through heavy gauge flame retardant rigid PVC conduits. All wiring for alarm circuits shall run through steel conduits.

F. Validation

The control system contractor shall completely check out, calibrate and test all connected hardware and software to insure that the system performs in accordance with the approved specifications and sequences of operations submitted.

- Witnessed validation demonstration shall consist of :
- Demonstrate alarm sequence.
- Execute manual override commands.
- Display and demonstrate panels man/machine interface functionality.

G. Manuals

The following manuals will be provided :

- An Operators Manual shall be provided with graphic explanations of keypad use for all operator functions specified under Operator Training.
- Computerized printouts of all panel data file construction including all point processing assignments, physical terminal relationships, command and alarm limits, etc.
- A manual shall be provided including revised as-built documents of all materials required under the paragraph "SUBMITTALS" on this specifications.
- Two sets of manuals shall be provided to the owner.

COLLECTIVE ANTENNA TV SYSTEM (16780)**A. Generalities**

The Contractor shall supply and install, as specified and shown on drawings, a Master Antenna TV System Work is deemed to include; at least:

- Cables, Outlets, in addition to any accessory deemed necessary to the system.
- Mounting and installation accessories

B. System components**B.1 Cables**

Coaxial cables must provide the least attenuation for all channels. The attenuation difference at 100 m between the lowest VHF signal and the highest one must not exceed 13 db. Typical volume attenuations at 50 Mhz is 5 db and 18 db at 800 Mhz. The coaxial cable to be used for the parabolic antenna must not provide an attenuation greater than 28 db for a 100 m distance at 1800 Mhz.

B.2 Outlets

These outlets must be of the standard product. The contractor must ensure a directional attenuation greater than 40 db between two outlets. The signal level at each outlet must be greater than 60 db. The outlets must be of the same range as that of the wiring devices (switches, jacket outlets, etc.)

B.3 Miscellaneous

An earthing connection same as that recommended by the standards and the manufacturer is to be provided for the whole installation. This earthing must be similar to the one described in the "Earthing System".

Coaxial cables connecting the parabolic antenna and the antennas to the modulators and amplifiers must be supplied with overvoltage suppressors and filters. The coaxial cables screen must be connected to the earth.

C. Submittals

The following data (but not limited to) are to be provided :

- Manufacturer's catalogue cuts.
- Cabling and wiring diagrams.

ACCESS CONTROL SYSTEM (16730)

A. The System

The Security Management System should be capable of Controlling and Monitoring Access through the doors, Monitor and control Inputs and Outputs, include an Integrated Video Badging, Integrate Elevator Control and Seamless Integration to Digital Video Recorder and control CCTV functionality. The software should be capable of recording events in such a way that they are recorded whenever an access is granted/denied or access granted during programmed schedules or holidays etc.

Pop up screens should display the video if the Access points or input points are tagged to those points in case of alarm. This should be programmable by the operator. The system should also have video verification capability where the guard could verify the person before granting access through the software and from the video. The guard should have a single screen wherein he can see the Video as well as have the card details of the person accessing the door with his photo from the file. The system should also have a High security mode wherein only privileged card holders can have access to the facility and this should be programmable to be based on events or per a programme time schedule. This should be flexible and should be easily programmed to suit any specific needs.

The system should also provide Time & Attendance information such as Name, In Reader location, Out Reader Location, IN time, OUT Time and the number of hours worked along with other system reports. The data should be exported to any payroll or HR package in various different file formats. Whenever a card holder presents the card at the reader the system should be capable of displaying the Video from the camera focused on the door plus bring in his card details from the database on a single screen for verification. It should also be possible to verify at a later date if the access has been not been misused.

The system should also be capable of recording events automatically on any compatible DVR and should be able to retrieve recordings based on events.

B. System Overview:

B1 General Overview

Functions of the Integrated Access Security Management System (ISMS) shall include:

- Granting or denying access to secured areas.
- Controlling access point features and modes.
- Alarm input and abnormal access point activity monitoring.

B2 Output control.

System configuration and management functionality to facilitate functions listed above.

Reporting of the events generated by the functions listed above.

B3 System configuration reporting.

Facilities to automate event search on connected Digital Video Recorders (DVR).

Integrate seamlessly with any compatible DVR and control CCTV functionality. Control Elevator Access to the floors based on Access permissions. Elevator Controller allows control of up to two elevator cabs with 8 floors total. Can be expanded to control up to 32 floors. It should utilize flash firmware for easy upgrades and employs fully distributed intelligence for off-line operations.

B4 Integrate with third party Alarm panels

The software should be capable of producing ID badges and printing them on any suitable card printer

With optional modules the system should be capable of controlling upto 4 doors per panel or 4 doors with IN/OUT capability

C. System Architecture

ISMS shall consist of the following:

C1 Server Software package, with following functions:

- User interface for system control and configuration.
- Field hardware communication functionality.
- Live activity and status display.
- System and event history reporting functionality.
- Server for the Client Software packages.

C2 Client Software Packages, with following functions:

- User interface for system control and configuration.
- Live activity and status display.
- System and event history reporting functionality.

C3 Intelligent Field Panels, supporting:

- 2 access points.
- Local means of control trough system and panel links as well as reader and reader/keypad input.
- Field interface to access control readers of various types.
- Field interface to variously configured alarm inputs.
- Control relay and voltage outputs.
- Communicate with the Server Software package, by means of:
 - Direct RS-232 connection
 - Direct or networked RS-485 connection.
 - Direct modem connection (Utilizing external modem)
 - Direct TCP/IP connection (Utilizing TCP/IP gateway).
- Convert RS-232 into RS-485.

D. Operational Features

D1 Access Points:

➤ Access point shall be configured to:

- Auto-relock, when door is closed. Overriding unlock timer.
- Deduct usages from cardholder's balance.
- Report or not to report door forced open events.
- Unlock based on a schedule.
- Require System Operator's decision to grant or deny access to cardholder requesting access by use of a card.
- Conform to "first person delay" rule of the scheduled unlocking.

- If specified bypass door contact only without activating lock output following request to exit activation.
- If specified deny access to cardholders without High Security privilege.
- If specified operate in site code only mode.
- Report or not to report request to exit activations.
- Report or not to report failure of a cardholder to open the door following a valid card use.
- Report or not to report invalid card format event.
- If specified require both card use and PIN entry based on a schedule.
- Function in timed anti-passback mode with a specified delay if required.
- Function in true panel or global anti-passback mode with either hard or soft enforcement if required.
- Associate with entering and exiting pre-defined areas.
- Initiate display of the cardholder's information and picture on Server and Client software packages, based on Access Granted and/or denied and/or requested.
- Initiate recording on any compatible DVR based on programmed events on the Access points.
- POP up video of the designated camera in case of alarm
- Allow Elevator Access to designated floors.

➤ Access Points shall be granting or denying access to a secured area, based on:

- Access Level permissions, specifying an independent access schedule for each access point.
- Status of the card.
- High security privilege.
- Current usage balance.
- Anti-passback status or privilege.
- Card de-activation date and time.
- Card and PIN match.
- Site code mode.
- Manual command based on access request.
- RTE input activation.

➤ Access point shall lock and unlock:

- Manually, through system command.
- Manually, through double consecutive use of an authorized card.
- Manually or automatically, through panel or system linking.
- Automatically, based on schedule.
- Automatically, based on schedule and first valid card use.

➤ Modes of the access point shall be controlled:

- Manually, through system command.
- Manually, through quadruple consecutive use of an authorized card (See High Security Mode).
- Manually or automatically, through panel or system linking.

- Access point shall possess convenience features for handicapped cardholders:
 - Extended unlock time for designated cardholders.
 - Activation of an additional output for designated cardholders.
- Access point shall provide reporting of the following events:
 - Access granted, requested.
 - Access denied with a specific reason.
 - Door held open warning.
 - Door held open alarm.
 - Door locked and unlocked.
 - Forced entry.
 - Restore.
 - Door not open alarm, following card access granted.
- Access point shall have capability to trigger Recording on any compatible DVR, panel and system links by:
 - Access granted or denied events.
 - Door held open warning.
 - Door held open alarm.
 - Door locked and unlocked events.
 - Forced entry event.
 - Restore event.
 - Door not open event, following card access granted.
- Access Point shall be associated with a specific camera on a specific compatible DVR (addressed by IP address and port) for automated video retrieval and display of live picture from the camera associate with it.

D2 Alarm Inputs.

- Alarm input shall be configured to report various messages to Server software package with abilities to:
 - Specify in which state (never, armed and/or disarmed) a specific alarm input reports.
 - Suppress individual message types of a specific alarm input based on a schedule.
 - Display a pre-defined message for each event type of a specific alarm input.
- Alarm input shall have the ability to be configured with a delay on alarm reporting.
- Alarm inputs shall be armed and disarmed:
 - Manually, through system command.
 - Manually or automatically, through panel or system linking.
 - Automatically, based on schedule.
- Alarm input shall provide event reporting of the following events:
 - Input alarm.
 - Input restore.
 - Input trouble.
 - Input normal.

- Input abnormal.
- Force armed.
- Alarm input shall trigger panel and system links by:
 - Input alarm and restore events.
 - Input trouble event.
 - Input normal and abnormal events.
- Alarm input shall be associated with a specific camera on a specific compatible DVR (addressed by IP address and port) for automated video retrieval.
POP up video of the designated video in case of alarm

D3 Outputs.

- Outputs shall be configured as:
 - Fail-safe or fail-secure.
 - Reporting or non-reporting to the Server Software package.
- Outputs shall be activated and deactivated:
 - Manually, through system command.
 - Manually or automatically, through panel or system linking.
 - Automatically, based on schedule.
- Output shall provide event reporting of the following events:
 - Output on.
 - Output off.
- Output shall trigger panel and system links by:
 - On and off events.
- Alarm Output shall be associated with a specific camera on a specific compatible DVR (addressed by IP address and port) for automated video retrieval

E. Hardware Specifications:

E1 Intelligent Field Panel (IFP)

The panels should be UL listed and also comply with FCC and CE regulations

- IFP Architecture:
 - IFP shall utilize a fully distributed intelligence controller architecture whereby access decisions are made locally at the controller.
 - IFP shall utilize flash firmware for easy upgrades.
 - IFP shall support two access points.
 - IFP should be capable of expanding the functionality of the two access points to two access points IN/OUT, making the IFP a 4 reader controller.
 - IFP shall support local means of control through system and panel links as well as reader and reader/keypad input.
 - IFP shall support field interface to access control readers of various types.
 - IFP shall support field interface to eight variously configured alarm inputs.

- IFP shall control four relay and four voltage outputs.
- The Server software package (host computer) shall download panel specific data, including up to 8,000 cardholders, to the IFP on the network. This data shall be stored within each panel and contain all pertinent information relating to the panel's functionality.
- Host computer shall communicate global links and anti-passback messages between panels.
- Should communication with the Server software package (host computer) be lost, up to 3,000 time-stamped events shall be stored in panel's buffer, until communication is restored. Upon restoration of communications all event data shall be automatically uploaded to the host computer including the actual time of occurrence.
- This functionality shall enable any off-line controller to maintain full access control processing capability. A card user shall not be aware of the off line condition.
- A system that does not buffer event information when communications are lost will not be acceptable.

➤ IFP communications:

- Host computer shall support up to 16 networks with a maximum of 32 panels connected, upgradeable to a maximum of 64.
- Up to 16 Intelligent Field Panels shall be connected on a hard wired network.
- Following means shall be used to connect a hard wired network of panels to the host computer:
 - a) Direct RS-232 (three wire)
 - b) Direct RS-485, utilizing RS-232 to RS-485 converter.
 - c) Dial-up, utilizing external modem connected via RS-232 (4 wire) with modem power reset capability in IFP.

TCP/IP, utilizing a field configurable network gateway.

- The hardwired communication network shall be wired with 18AWG twisted-pair, shielded cable. The hardwired network shall have maximum length of 4,000'. This network shall be wired in a daisy chain configuration.
- System shall be configured to report various panel communications status messages to the Server software package with abilities to:
- Suppress individual message types of a specific alarm input based on a schedule.
- Display a pre-defined message for each event type of a specific alarm input.
- System shall provide event reporting of the following events:
 - a) Panel online.
 - b) Panel offline.
 - c) Panel trouble.

➤ IFP hardware configuration:

- Panel Addressing
 - IFP's address shall be set via four onboard dip-switches.
 - Available addresses shall be 1 through 16.
- Communications speed settings
 - IFP's communications speed shall be set via two onboard dip-switches.
 - Available rates shall be 9.6, 28.8, 38.4 and 56 kbps.

- Modem configuration
 - IFP's modem communications shall be enabled via an onboard dip-switch.
 - Selection between dial-up and direct network shall be available.
- Host or network setting
 - IFP's location on the network (connected to the host vs. RS485 network connection) shall be enabled via an onboard jumper.
- RS-485 Tuning
 - IFP shall provide means of RS-485 network tuning, specifically:
 - Low bias.
 - High bias.
 - Termination.
 - IFP tuning shall be accomplished by adjusting onboard jumpers.

➤ IFP Reader Interface

- IFP shall provide interface to access control readers utilizing either magnetic stripe or Weigand electrical formats.
- IFP shall support up to 5 different card formats simultaneously.
- IFP shall support all major reader technologies:
 - Proximity
 - Magnetic Stripe
 - Weigand
 - Bar Code
 - Keypad Only
 - Proximity with Integrated Keypad
 - Magnetic Stripe with Integrated Keypad
 - Hand Geometry
 - Fingerprint
- IFP shall provide dedicated control over Red and Green LEDs for each access point.
- IFP shall provide dedicated control over Buzzer for each access point.
- Wire lengths of 500' utilizing 20AWG and 250' utilizing 22AWG 6 or 8 conductor shielded cables shall be required.

➤ IFP Alarm Inputs:

- IFP shall provide eight fully programmable alarm inputs.
- Each alarm input shall support all of the following circuit types:
 - N.O. Non-supervised.
 - N.C. Non-supervised.
 - N.O. Supervised with one resistor.
 - N.C. Supervised with one resistor.
 - N.O. Supervised with two resistors.
 - N.C. Supervised with two resistors.
- Combination N.O. and N.C. Supervised with one resistor.
- Wire lengths of 1,000' utilizing 20 or 22AWG cables shall be required.

- IFP Outputs:
 - IFP shall provide eight fully configurable outputs (four relay and four voltage ones).
 - Each output shall be configured as fail-safe or fail-secure.
 - Relay output shall be rated 2A @ 30VDC.
 - Voltage outputs shall switch negative 12VDC @ 100mA.
- IFP Enclosure:
 - Height: 12"
 - Width: 14"
 - Depth: 3 1/2"
- IFP Environmental tolerances:
 - Operating temperature: 35-150°F
 - Operating humidity: 20-80% RH (non-condensing)

F. Reports:

F1. Time and Attendance Reports

The system should also provide Time & Attendance information such as Card Holder Name, In Reader location, Out Reader Location, IN time, OUT Time and the number of hours worked and also calculate the number of hours worked for a certain time period, say a week etc. This should be in addition to a number of other reports being able to be generated from the system. The data should be exported to any payroll or HR package in various different file formats.

Whenever a card holder presents the card at the reader the system should be capable of displaying the Video from the camera focused on the door plus bring in his card details from the database on a single screen for verification. It should also be possible to verify at a later date if the access has been not been misused. All such transactions should be capable of being stored in the database as well as on any compatible DVR.

STANDBY POWER GENERATORS (16620)

A. Generalities

The contractor is to supply and install emergency generators including:

- Three Generators.
- Control, regulation and protection panelboards for the generator
- Synchronizing and coupling Totalizing panelboard for the three generators.
- Auxiliary panelboards
- Starting system
- Fuel supply system
- Exhaust system
- All related electrical installations
- All related fuel installations
- All other necessary accessories

B. System operation

B1. Automatic Mode

- In normal ways, the mains supplies the whole installation.
- Upon receiving a signal from the voltage supervisory system indicating a voltage anomaly on the local network, the sets are to start simultaneously meaning an adjustable time switch (0-2 minutes)

B2. Manual Mode

This mode must allow each generator to run in the presence or absence of any load and to shut down manually or meaning a push button.

B3. Test Mode

This mode must allow the sets to start and synchronize without any load while the mains are available. Switching to the "automatic" or "out-of-order" mode are the only ways to shut down the generators.

If the starting signal is received during the "test mode", then the generators must supply the load automatically.

B4. Out-of-order Mode

This mode forbids the starting of the generators in any case. Switching to this mode stops the set immediately.

C. Electrical equipment

C1. Generating set panelboard

Each generator is to be provided with a panelboard made of 20/10 thick sheet steel supplied with lockable doors, painted with a finish in accordance with the client's choice. Cables are to be installed in adequate plastic trunking. This panelboard includes:

- a. Selector Switches:
 - Running mode selector
- b. Push buttons:
 - Emergency stop
 - Engine starting
 - Engine stopping
 - Lamp Test
 - Alarm cleared
 - Alarm sounder off
- c. Protection and Control
 - Alternator overload protection
 - Alternator output protection: Voltage, frequency, ...
 - Active power protection
 - Alternator cables protection
 - Preheating water relay
 - A set of time activated and instantaneous relays allowing the starting and shut down of the generators in addition to the indicating lamps.
- d. Metering apparatus
 - 3 ammeters with their current transformers.
 - Voltmeter
 - Power factor meter
 - Hourmeter
 - Frequencymeter
- e. Indicating lamps
 - Generators' voltage availability
 - Oil preheater on
 - Water preheater on
 - Water preheater failure
 - Oil preheater failure
 - Emergency stop on
 - Oil temperature failure
 - Water temperature failure
 - Oil pressure failure
 - Overspeed
 - No Starting
 - Charger failure
 - Batteries failure
 - General electrical failure
 - Alternator voltage off
 - Irregular alternator voltage
 - Overload
 - Daily fuel tank low level

- Daily fuel tank high level

C2. Synchronizing and coupling panelboard

This panel is to be made of sheet steel 20/10 thick, with integrated lockable doors, painted to the request of the client.

This panel will include all necessary equipment to ensure synchronizing of generators and coupling.

C3. Synchronizing system

- a. An automatic synchronizing system shall be provided to control the paralleling of generators sets acting on their speed regulators and phase angles and prohibiting any faulty coupling.
- b. A manual synchronizing system shall allow the manual paralleling of generating sets. This system will include:
 - Two voltmeters to measure generator and parallel busbar voltage
 - Two frequency meter to measure generator and parallel busbar frequency
 - One synchronoscope
 - Two synchronizing pilot lamps
 - Coupling selectors
- c. On the front door of this panel are mounted the following equipment:
 - Two Wattmeter
 - One selector switch "Off-Manual-Auto"
 - Two selector switches for closing/opening of generators circuit breakers
 - Two speed potentiometers
 - A test lamp push button
 - A fault reset push button
 - Pilot lamps: DC power failure, coupling fault, Main emergency stop.

C4. Load Sharing and load supervision system

This system shall allow the starting and shut down of the generators according to the required power supply.

The automatic system must include consumption measuring equipment. When the required consumption becomes greater than 70% of the in-service generator(s) power, the next generator is to start, after a predetermined time (few minutes) and supply the new demand.

The reverse mode shall be assured by the shutdown of the last generator to enter the system, after a predetermined time, when the consumption becomes less than 30% of the available power on the emergency busbar. This is to be valid except when only one generator is in service.

(x) These percentages as well as the starting sequence could be modified by the user. If one generator is out of service, a load supervision system will allow a load shedding in order not to overload the running generators. Once the generator is repaired and connected to the emergency busbar, the non-supplied loads are to be connected automatically.

If the frequency on the emergency busbar decreases, then the load supervision system is to shut down some loads. If this decrease persists, then the load supervision system must continue the shutdown of loads, at 10 seconds intervals (adjustable), until the frequency reaches its normal stability. In this case, the load supply will be manually governed according to a predetermined program of priorities.

C5. Auxiliaries Panelboard

This panel is to be made of 20/10 thick sheet steel, and includes, at least, the control and protection devices of the following auxiliaries:

- Water preheater
- Oil preheater
- Automatic battery charges (protected on AC and DC sides)

This panel will include also the following:

- Indicating lamps showing the status of the auxiliaries
- A voltmeter that controls the charger voltage
- An ammeter that controls the charging current.

D. Motor

The following characteristics are to be observed:

- Barometric pressure: 736 mm Hg
- Relative humidity: 60 %
- Ambient temperature: 45°C
- Ambient conditions: Dusty
- Cooling mode: Water or air
- Maximum consumption: 180 grams / Hp/hour

The manufacturer shall determine his choice of diesel motor according to the site climatic and geographic conditions as well as to the projected running mode.

D1. Motor Description

The motor is of the mechanical or pneumatic injection type with a maximum rpm of 1500.

All parts must be easily accessible.

Greasing must be done under pressure. In case of low pressure, a monometer provided with electrical contacts will automatically shut down the generator and initiates the relative alarm.

A speed regulator will insure the speed steadiness. The difference between running on no load and with full load must not exceed 2% of the speed. In normal modes generator for fixed loads, the allowable maximum difference is $\pm 1\%$ and the generators inertia flywheels are to be sized accordingly.

The return to standard speed is to be achieved in less than 3 seconds while passing from the no load mode to the full load mode and vice versa.

All rotating/movable parts such as flywheel must be protected with caps or fence if they are accessible.

D2. Standard equipment

- Diesel motor operating on domestic fuel
- Inertia flywheel
- Speed regulator
- Underpressure greasing circuit
- Electric starter
- Dry Air filter
- Oil filter
- Fuel filter and prefilter
- Water thermostatic valve

- Manual Pre-greasing pump and oil drain
- Oil cooling agent
- Manual oil greasing and drainage
- System keeping the oil at an admissible temperature. If this device includes parts subject to wear, it should be of the duplex type.
- All electrical installations & piping must be solidly fixed in order to withstand vibrations.
- Systems dedicated to protect the motor in the following cases:
 - If the oil pressure drops below a preset limit.
 - If the oil and water preheating is not ensured.
 - If the cooling water temperature rises above a preset limit.
 - Overspeed

D3. Motor Control Panel

The motor shall be provided with a control panel, which must not be fixed on any part subject to vibrations. This panel, includes at the front, the following:

- Time
Hour meter with a 10,000 running hours totalizer (sealed)
- Oil
Manometer and thermometer installed on the greasing circuit.
Alarm contacts relative to minimum pressure and temperature excess are to be wired to this panel in order to be connected to the main control and regulation panel.
- Water
Thermometers relative to high and low temperatures are to be provided.
A contact relative to temperature excess is to be wired to this panel in order to be connected to the control and regulation panel.
- Engine starting
On / Off push buttons.
Note:
The motor is to run in a continuous mode without the need of any additional precautions other than those required for the normal maintenance (Oil filled).

E. Alternator

The Alternator shall be synchronous, four pole, revolving field, drip proof construction, single prelubricated sealed bearing and directly connected to the engine.

E1. Alternator Characteristics:

- Rating as indicated on the drawings
- Power factor:0.8
- Voltage:380 V
- Connection:star with neutral
- Frequency:50 Hz
- Speed:1500 rpm
- Insulation class:H
- Service: continuous

- Overload: 10 % for one hour every 12 hours

E2. Electrical characteristics:

Voltage regulation must be done at $\pm 1.5\%$ of the nominal voltage irrespective of the set status and in the following cases:

- When the load varies from 0% to 100 %
- When the power factor varies between 1 and 0.8
- When the speed varies between the admissible limits.

Time response must be less than 5 seconds. The alternator must be the only equipment that is connected to any other one subject to vibration.

Mechanical characteristics

The alternator and its (exciter) must be protected against vertical water flow. The location of connection boxes must be defined according to the power cables routing.

The alternator must be provided with handling devices. Cable entrances must be done thru cable glands.

E3. Electrical Protections

The alternator will be protected at the low voltage side by:

- An external fault relay between phases
- An overload and imbalance relay (2 thresholds: 1.5 In with timer and 1.8 In)
- Stator earth leakage relay

F. Oil and water preheating

A preheating system for oil and water circuits is to be provided using an electric heater. The activation is controlled by a thermostat (one for each resistor). The preheater will stop automatically when the set starts.

A switch, installed in the auxiliaries control panel, will control this system. Indicating lamps are to be provided.

G. Starting system

The system will include:

- A set of Nickel cadmium batteries. The capacity shall be adequate to ensure six consecutive starts.
- An automatic charger
- Support structure
- Cables and wiring devices
- All accessories deemed necessary for the system
- Maintenance accessories
- Selector switch to activate the system

H. Fuel system

Each set will be supplied from a 500 L daily tank made from welded steel and installed on a metallic structure.

Each tank will be equipped with:

- A level indicator
- A vent

- Supply and drain valves
- Filling and return points
- A security valve installed outdoor
- A retention tank of 600 L capacity
- An automatic filling system
- Low level and high level detection
- Electro-pump for automatic filling
- Manual pump.

I. Submittals

The following data (but not limited to) are to be provided:

- Manufacturer's catalogues, specifications and data sheets.
- Shop drawings showing plan and elevation views of generating sets, panelboards and system components, including overall dimensions, weights and required clearances.
- Single line diagram showing power cable and control wiring between system components.
- Manufacturer's certification of prototype testing.
- Manufacturer's published warranty documents.

J. Approved Manufacturers (Shall be assembled in the Country of origin)

- CATERPILLAR CUMMINS
- PERKINS
- USA ENGLAND
- GERMANY

LIST OF ELECTRICAL APPROVED MATERIAL

ITEM	MATERIAL
1. PANELBOARDS	
1.1 Main distribution Panelboards	MERLIN GERIN, ABB
1.2 Power and Lighting Panelboards	MERLIN GERIN, ABB, LEGRAND BTICINO
2. WIRES CABLES AND FEEDERS	LIBAN CABLES, BICC, PIRELLI
3. CONDUITS AND WIREWAYS	
3.1 Cables trays	TOLAROIS, OBO BETTERMANN
3.2 Conduits	UNIVOLT, PM
4. LIGHTING FIXTURES	In addition to those listed in the specifications: PHILIPS, HOFFMEISTER, ERCO, IGUZZINI
5. WIRING DEVICES	LEGRAND (MOSAIC 45), GEWISS (PLAYBUS), TICINO (LIVING)
6. FIRE DETECTION SYSTEM	AS EXISTING.
7. COLLECTIVE ANTENNA TELEVISION	AS EXISTING.
8.. TELECOMMUNICATIONS INSTALLATIONS	AS EXISTING.
9.GENERATORS	CUMMINS CATERPILLAR PERKINS
10.. SURGE ARRESTERS	DEHN J PROPSTER KRONE