CONSEIL DE DEVELOPPEMENT
ET DE RECONSTRUCTION

REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION

Harbata Governmental Hospital

VOLUME 2- SPECIFICATIONS

MECHANICAL WORKS

MAY 2025

SPECIFICATIONS

INDEX

DIVISION 15

MECHANICAL WORKS

INDEX

Division 15

MECHANICAL WORKS

PROJECT OUTLINE AND DESCRIPTION (15005)

A. General

This Book of Specifications covers the General and Particular Specifications for the Mechanical Systems.

B. Project Outline

The project consists of whole mechanical works as mentioned in drawings specifications and BOQ.

C. General Description of the Works

The following Mechanical Systems are included in the Project:

a. Water Supply.
b. Sanitary Drainage.
c. Rain water and surface drainage.
d. Fire fighting.
e. Domestic fuel oil distribution.
f. Air Conditioning.
g. Heating.
h. Ventilation.
j. Medical gases, vacuum & compressed air.
k. Electrical works related to the Mechanical Works.

as described in the following clauses and/or shown on the relevant Tender Drawings.

D. Soil and waste disposal installation

The system shall be a conventional gravity drained combined soil and waste network, primary and secondary vented for all the floors.

Piping are interconnected to a main collecting manhole and then drained to the municipal sewer network of the region in waste drains

E. Rain water drainage system

The rain water drainage system will be a conventional roof drainage system. A set of roof drains and vertical drain pipes running down to discharge at ground level.

F. Domestic water distribution system

F2. Cold Water Supply

- City water is provided to the Health Center by means of one gauge.
- Chlorination station including chlorine storage tank and feeder are provided to sterilize the city incoming water.
- City water is then stored in the underground (existing) water storage tank.

- Pumping set shall transfer water to a storage tank at upper roof level via a filtration plant including sand filter.
- Treated water (sterilized and filtered) will supply via a booster set sanitary fixtures.
- A separate branch of treated water shall supply hot water storage tanks, laundry, laboratory, pharmacy, sterilization room and surgery via a softening system including 2 softeners.
- Additional branch of treated water by Reverse osmosis shall be provided to feed the medical equipment where required.

F3. Hot Water Supply

- Hot water shall be provided to the project by means of hot water storage plant via two separate circuits :
  a. One circuit providing hot water to kitchen and laundry (60 °C)
  b. One circuit for the other fixtures

G. Irrigation water distribution

A booster shall provide water to irrigation faucets via the basement water storage tank.

H. Fire fighting system

Fire fighting system shall consist of:

- $25m^3$ water reserve in the roof storage tank.
- One hydropneumatic system installed at 1^{rst} basement level to provide fire fighting flow and pressure requirements.
- Hose reels installed in appropriate place at each floor level.
- Fire Siamese connection provided at the entrance to the project.
- Fire extinguisher installed in the cabinet of each hose reel, and in every hazardous place.
- Carbon dioxide fire suppression system in the boiler room.
- Special liquid suppression fire fighting system for the kitchen hoods.
- INERGEN GAZ suppression system in the generator room.

J. HVAC System

J1. Basic Data

The system is designed according to ASHRAE recommendations.

1. Climatic Conditions
   The system is designed to provide the inside conditions below noted, when the outside conditions are as stated:

	Summer		Winter
	DB (°C)	RH (%)	DB (°C)
a. Internal Conditions			
• Surgical	20 - 24	50 - 60	24
• recovery	24	50 - 60	24
• Delivery	20 - 24	50 - 60	
• Radiology	24	50 - 60	24 - 27
• Others : Patient areas	24	50 - 60	24
Non patient areas			21
b. External Conditions			
Dry bulb temperature	33		1
Wet bulb temperature	25		--

2. Lighting 20 W/m²
3. Ventilation

   The main recommended air change per hour shall be as following:

Area	*Minimum air change per hour*
– Surgery	15
– Delivery	15
– Sterilization	2
– Recovery	2
– X Ray	2
– Pharmacy	2
– Laundry	10
– Storage	2
– Laboratory	2
– Emergency	2
– Toilets	10
– Kitchen	12
– Autopsy	12

4. Permissible Sound Level

   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)

J2. System Description

1. Air Conditioning

The chilled and hot water system is of the four pipes system for and operating rooms, and two pipes for other areas. Kitchen ,Laundry ,Autopsy, and X-ray rooms are provided with cooling only Hot water generated by the boilers and chilled water generated by the chillers, are circulated in the piping system (four pipes) simultaneously, hot or chilled water is circulated through the fan coil units depending on whether heating or cooling is required in the relative zone.

This system shall include:

- Chilled water generating station which consists of 2 air cooled chillers, cooling only, 1000T.R. installed on site plan.
- Hot water generating station which consists of 3 boilers, 200 000 kcal/h capacity each.
- 2 central pumping stations (one for cooling, one for heating).
- Piping system including four pipes (two for cooling & two for heating) providing chilled and hot water to the terminals (fan coils units and air handling units with dual coils) installed in air conditioned spaces in the basement and delivery room.
- Piping system including two pipes providing chilled or hot water to the terminals (Fan coil units and air handling units with one coil), for the other air conditioned areas.

Operating room

1. There shall be a variable range of temperature capability of 20 to 24^{o}C.
2. Relative humidity shall be kept between 50 and 60%
3. Outside air shall be provided directly to the correspondent air handling unit. Every AHU shall be operating simultaneously with an extract fan. The system shall maintain a positive air pressure with respect to the adjoining rooms by supplying 15% excess air.
4. Humidity indicator and thermometers shall be located for easy observation.
5. Filter efficiencies shall be 99.9%.
6. All outdoor air system shall be adopted with two speed fans. The low speed shall be selected when the operating room is not occupied.

2. Ventilation

Central fresh air air hanling units with energy recovery units , 2 pipes coils , are provided and installed in the attic to provide treated fresh air for the whole hospital.Related central exhaust system is provided to be exhausted through the energy recovery units.

Special dirty ares such as autopsy, waste treatment , garbage room, medical gases , isolation room and laboratory , are provided with individual exhaust fans , with no energy recovery.

3. Heating system

Heating system consists of the following:

- Hot water generating station which consists of 3 boilers, 200 000 kcal/h capacity each.
- Primary pumping set including one pump on each boiler.
- Secondary pumping set including the following pumps :
  - One set of two pumps for each heating circuit as shown on schematic riser
  - One set of two pumps for domestic hot water heat exchangers.
  - One set of two pumps for fan coil and air handling unit heating coil, one stand by.

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. Al 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 is 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 (ºC)	RH (%)	DB (ºC)
a. Internal Conditions			
• Surgical	20 - 24	50 - 60	24
• recovery	24	50 - 60	24
• Delivery	20 - 24	50 - 60	
• Radiology	24	50 - 60	24 - 27
• Others : Patient areas	24	50 - 60	24
Non patient areas			21
b. External Conditions			
Dry bulb temperature	33		1
Wet bulb temperature	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 supports Black

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.

Control and power wires are shall be identified either by distinctive colored insulation, engraved tags or other approved method.

t. Circuit breakers earth fault detection and interruption are shall be coordinated with those of main incoming breaker on main distribution panel.

u. 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 are 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 are 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/cm^2. Switch shall be good for 1720 kPa operating pressure and shall have 6 mm pipe tap bottom connection. It is 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 is 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 nonflowing 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 alternations 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 90oC.
- 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
11/4"	2.5	10
11/2"	2.7	10
2"	3.0	10
21/2"	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		Minimum Size of Hanger Rod
	Horizontal Pipes(cm)	Vertical Pipes (cm)	
1/2"	60	120	10 mm
3/4"	70	140	10 mm
1"	75	150	10 mm
11/4"	80	160	10 mm
11/2"	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

ALVES 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^{o}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^{o} F, specifically supplied for the nominal pipe size. Density shall not be less than 6 lbs per ft^{3}.

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 is shall be calcium cilicate 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/cm^2
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^{o}C.

D. CO_2 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, hangers 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 shut-off 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 runtime 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 runtime 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 200ºF (93ºC).

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 m^3/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.

HEATING PLANT (15450)

A. Oil fired boiler (Cast iron)

supply and install cast iron boilers wherever shown on the drawings and as specified herein :

Boiler shall be of the cast iron sectional type rated for 88.5 psi (610kpa). Each boiler shall be complete with the following :

- Automatic, high pressure, gun type burner suitable for light oil No.2 atomatization.
- Fuel oil solenoid valve.
- Burner plate
- Insulated and enameled steel jacket and fire bricks.
- 4mm thick steel breaching with 2” (50mm) insulation, connecting the boiler with the chimney.
- Draft control damper
- Thermometer
- Pressure gauge
- Aquastat
- Pyrostat or photocell
- Safety relief valve
- Electric control panel complete with switches and pilot lights and all electrical wiring.

The aquastat shall control burner operation to maintain water leaving the boiler at 180^{o}F (82^{o}C) and the pyrostat or the photocell shall monitor burner operation and stop it in the event of flame failure or if combustion does not take place.

B. Domestic hot water tank (heat exchanger)

Suuply and install domestic hot water tank wherever shown on the drawings and as specified herein :

- Tank shall be constructed of welded sheet steel galvanised after fabrication. Tank shall be of the tube in shell storage type for vertical mounting, built for indirect heating with large heating surfaces.
- Tank shall be tested for 177 psi (1220 kpa) and suitable for 88.5 psi (610 kpa) working pressure.
- Each tank shall be complete with the following :
  - Gate valves at each inlet and outlet.
  - Automatic air vent
  - 2” (50mm) thick fiberglass insulation with wire mesh and two coats of starch soaked heavy cloth
  - Steel saddles and frames necessary for installation
  - All motorized valves, control panel, wires, and accessories required for proper operation.

C. Central heating water pumps

Supply and install, wherever shown on the drawings and as specified herein, all central heating water pumps.

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 200ºF (93ºC).

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 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.

D. Main Fuel Tank

Supply and install main fuel tank wherever shown on the drawings and as specified herein:

Tank shall be cylindrical, fabricated from 6mm thick high quality black steel plate welded on both internal and external seams.

Hydrostatically test tank at factory to pressure of one atmosphere held for 24 hours. All welds shall be proven sound.

Manhole shall be 500 mm diameter on top of tank, constructed from 6 mm thick side, flange and cover welded to tank. Cover shall be fixed to flange with 1.5 mm thick asbestos composition ring gasket and 20 mm diameter machine bolts 40 mm long with nuts equally spaced around 600 mm diameter bolt circle.

Connections: tank shall have necessary female threaded connections comprised of black forged steel pipe couplings fitted through holes cut in tank and welded all around inside and outside tank.

Connections made to top of tank, except vent connection, are shall be extended down to within 150 mm of tank bottom with seamless black steel pipes of same size as connections and well braced to tank inside walls. Vent connection is not to extend more than 20 mm into tank.

Fill and sounding line connections shall have hinged lockable caps with 50 mm female threaded bottom inlets as manufactured by Buckeye, or approved equal.

Local tank level gauge: 20mm gauge glass of correct length, complete with 20mm gauge cocks, drain cock, and gauge glass protector as manufactured by Hatterseley.

Paint finish: tank, manhole and connections shall be thoroughly cleaned of rust, scale, slag, oil, grease and all foreign matter by sand blasting or wire brushing down to base metal and

painted on outside only with two coats of zinc chromate primer and two coats of emulsified asphalt.

Tank shall be built in accordance with UL standard for steel under ground tanks for flammable and combustible liquids UL. 58-1972.

Tank shall be equipped with the following :

- Remote reading, oil level gauge
- Fill and vent pipes
- Fuel supply and return lines
- Earthing connection

Tank should never be installed in, or covered with cinders to avoid rapid steel corrosion due to wet sulphur action.

Tank should be located outside the building with the top of the tank below the level of all piping to which the tank is connected. Tank should be buried so that the top of the tank is at least 600mm below grade. Otherwise, the top of the tank shall be covered with not less than 300mm of earth on top of which shall be placed a slab or reinforced concrete not less than 100mm thick. The slab should be set on a firm, well tamped earth foundation and should extend at least 300mm beyond the tank in all directions.

E. Expansion Tank

Supply and install expansion tank wherever shown on the drawings and as specified herein:

Closed type, including an interchangeable nitrogen bag tested to 7 bars at 110°C.

Horizontal or vertical closed vessel. One piece Butyl moduled bladder, fixed inside the vessel in one or two points. Bladder provides a complete separation between air and water, and is protected by filter.

Internal and external anti-corrosion paint.

F. Fuel Oil Circulating Pump

Supply and install fuel oil circulating pump set with two pumps wherever shown on the drawings and as specified herein:

The fuel oil circulating pump shall be centrifugal end suction type, Pedrollo or approved equal, and shall include :

- Cast iron casing
- Bronze impeller
- Carbon steel shaft
- Mechanical shaft seals
- The pump shall be bolted and grouted to a concrete base

The Contractor shall supply and install an electric panelboard for fuel oil circulating pump set including :

- The main disconnecting switches
- All necessary starters and controllers with alternate operation for pumps
- On/off default light
- Auto manual switch
- Magneto-Thermal protection for each pump

G. Fuel Oil daily tank

Supply and install fuel oil daily tank wherever shown on the drawings and as specified herein:

Fuel tank shall be rectangular shape fabricated from 4mm thick high quality black steel. The tank shall be reinforced and hydrostatically tested at factory after fabrication to a pressure of one atmosphere for 24 hours.

The tank shall be provided with steel legs at its bottom The

tank shall be complete provided with :

Fill connections ¾" diameter

One inch vent pipe.

H. Boiler breaching

Supply and install boiler breaching wherever shown on the drawings and as specified herein: Boiler breaching and chimney shall be black metal sheet not less than 5mm thick, painted with two coats of fire resisting paint, insulated with 5cm fire resisting insulation (rockwool), and covered with 0.6mm galvanised jacket. Clean up tight caps and doors shall be installed at every change of direction.

G. Raditor

Supply and install radiators wherever shown on the drawings and as specified herein:

Radiators shall be aluminum as manufactured by chappee, de dietrich or approved equal ,complete with all necessary accessories.

WATER TREATMENT SYSTEM (15482)

A. Sand filter

Supply and install sand filter wherever shown on drawings and as specified herein :

The filter shall be factory assembled :

- The casing shall be made of heavy gauge galvanised to resist to 9 bars operating pressure and shall be protected internally and externally by a thick epoxy coating.
- The media shall be made of calibrated gravel and silica materials.
- The filter shall be equipped with set of a butterfly valves and manometers on inlet and outlet.

The filtration velocity shall be less than 12m/h.

The service flow rate shall be $5m^3/h$

B. Chemical feeding system

Supply and install chemical feeding system wherever shown on drawings and as specified herein :

This system shall include :

- One pump to inject chlorine to sterilize the water

The pumps shall be similar to PULSAFEEDER, Electronic feeder type, capacity up to 30 gallons per day, pressure up to 80psi.

The metering pumps shall be supplied with four feet vinyl section tubing, and eight feet polyethylene discharge tubing. The digital timing circuit is highly reliable and by design, virtually unaffected by temperature.

The pump shall be internally dampened to reduce noise.

C. Water softener

Supply and install water softener wherevr shown on drawings and as specified herein:

Type : twin tank, fully automatic, package type, complete with brine tank, water meters, automatic controls and piping, completely assembled, wired and tested at factory, ready for installation and operation with simple water and electrical connections and of size and capacity to soften available water to zero hardness.

Brine tank : Shall be adequate size to provide minimum four regenerations of softener at maximum salt dosages and of fibreglass, rigid, sturdy, one piece open type construction with cover, designed to serve as combination salt storage and brine measuring tank. Perforated platform is to divide tank into sections with area above platform for dry salt storage and that below for brine generation.

Softener tanks : electric welded low carbon steel with dished ends double hot-dip galvanised after fabrication, designed and built for 6.9 bars (100 psi) operating pressure and tested at 10 bars (150 psi) hydrostatic pressure. Tanks are shall have access handhole at top with cover, steel structural legs, necessary female threaded connections and non-clogging stainless steel underdrain distribution systems designed for efficient flow distribution and requiring only one grade of supporting gravel. Each tank shall have multiport cast iron valve containing five integral diaphragm valves hydraulically operated by cycle controller in a smooth and water-hammer free manner and complete with self-adjusting brine injector.

Cycle controller : fully automatic, operated from automatic reset water meter to operate multiport valve and sequence the following regeneration operations on a gallonage basis : backwash, brine, slow rinse, down-flow flush and return to service. Position dial on controller is to indicate various steps of regeneration.

Electric alternator is shall be provided for the two softener tanks and is to comprise sequencing pilot and pressure switch integrated with multiport valve cycle controller to allow automatic alternate operation of softener tanks : one unit in service and second on standby. Signal source to actuate alternator is shall be supplied by automatic reset water meter.

Water meter : Shall be provided with each softener tank for installation on water outlet pipe from each tank. Meter is shall have automatic reset controller and electrical lockout device to prevent more than one softener tank from regeneration at one time and is to signal the regeneration cycle controller at a preset gallonage of softened water and then automatically reset for next service run.

Flow controller : each softener tank is shall have special factory-set flow controller to maintain proper backwash flowrate automatically over wide variations in operating pressures to prevent resin from being washed away during regeneration.

Automatic brine valve controlling brine withdrawal and fresh water refill is shall be provided in brine tank and housed in a tube sealed at bottom. Brine valve body shall be galvanized cast iron and other critical parts tough plastic. Brine valve shall have at least three steps of adjustment to allow operator to select salt dosage for most efficient and satisfactory operation for particular water condition.

D. Potable Water cartridge Filters

Supply and install a potable water filter at the discharge of the potable water pressure set as specified herein.

Cartridge water filter shall be single or multiple cartridge type elements designed to remove sand, dirt and rust color, odor taste and chlorine, and shall be complete as specified herein:

a. Stainless steel housing

b. Cellulose cartridge elements designed for cold water application.
The catridge is constructed of carbon-impregnated cellulose media, which is spirally wound around a polypropylene core polyester reinforcement backing, polyethylene outer sheath.
Filter elements shall have a nominal degree of filtration of five microns.

c. Unless specifically stated otherwise, filter shall be rated for 175 psi (12.3kg/cm²) working pressure.

d. Isolating valves, pressure gauges and cocks at inlet and outlet connections.

e. A bypass connection with gate valve.
Capacity and type of each cartridge water filter shall be as shown on the drawings and/or given in the Bills of Quantities.

E. Reverse Osmosis System

Supply and install reverse osmosis treatment system wherever shown on drawings and as specified herein.

E.1 Reverse Osmosis Unit

a. Packaged automatic reverse osmosis system mounted on steel frame, designed for project conditions. Equipment arranged on the frame to allow easy access for operating, maintenance and repair.

Performance Requirements:

1. Membrane reject ratio: 98% minimum. TDS of product is 2% maximum of input TDS.
2. Capture rate: 70% minimum. Maximum amount of water to drain 30% of input.

b. RO Membrane Elements:

Thin-film composite with FRP over-wrap, anti-telescoping device, u-cup brine seal. The design salt rejection shall be 98% based on 2000 ppm water at 225 psig at 77 degrees F.

c. RO Element Housings:

Type 304 stainless steel with PVC end caps held in place with stainless steel bands. Each housing assembly complete with one set of O-rings and O-ring lubricant. Housings for systems over 9000 gallons per day shall be constructed of fiberglass reinforced polyester (FRP). Provide cleaning connections.

d. High Pressure Pumps and Motors:

Vertical multistage high efficiency centrifugal type with Type 304 stainless steel casing, shaft, impellers. Tungsten carbide and ceramic shaft seals. Cast iron frame with flanged piping connections. Premium efficiency TEFC motor selected to be non-overloading on the entire performance curve.

e. Manual Valves:
    1. Pump Throttle Valve: Type 316 stainless steel ball valve, socket welded.
    2. Concentrate Throttle Valve, Recycle Throttle Valve: In-line needle style, stainless steel, rated for 300 psi minimum.
    3. Inlet Isolation Valve, Product and Concentrate Check Valves: PVC with EPDM seats and seals.
    4. Feedwater Sample Valve, Product Water Sample Valve: PVC plug valve with EPDM seats and seals.
    5. High Pressure Sample Valve: Type 316 stainless steel plug valve.

f. Automatic Valves:
    1. Automatic Inlet Shut Off Valve: Solenoid type, diaphragm actuated, normally closed, constructed of glass-filled Noryl thermoplastic.
    2. Automatic Membrane Flush Valve: Provide for purging the membranes with fresh water upon machine shut down.

g. Piping:
    1. Low Pressure Feed, Reject and Recycle Piping (75 psi and under): ASTM D1785, Schedule 80 PVC, socket welded and flanged.
    2. RO Product Tubing From Each Membrane Housing: ASTM D1785, Schedule 80 PVC, socket welded and flanged.
    3. Low Pressure Control and Pressure Gage Tubing: Polyethylene.
    4. High Pressure Reject and Recycle Piping (above 75 psi): ASTM A269, Type 304 Schedule 10 stainless steel with butt welded joints.
    5. High Pressure Control and Pressure Gage Tubing: 1000 psi burst nylon.

h. Controls:
    1. Electronic PLC or microprocessor controller providing automatic control for all operating functions. Motor starter panel. All in FRP enclosures rated NEMA 4. All wiring factory-installed and tested. Comply with Section 26 05 21, LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW) and NFPA 70.
    2. Autoflush indicator and control to flush RO concentrate at shut down or at predetermined intervals.
    3. Warning Alarms: Low quality product, low feed pressure, high feed temperature.

4. Automatic Shutdowns and Alarms: Low feed pressure, low product quality, pretreatment out of service, storage tank full.
5. Status Indicators: Low feed pressure, low quality, flow alarm, high feed water temperature, product divert to drain valve open, pretreatment lockout, storage tank full.
6. Pump Motor Starter: Comply with Section 26 29 11, LOW-VOLTAGE MOTOR STARTERS.
7. Miscellaneous Controls: Elapsed run time indicator, alarm horn, chemical pump receptacles, convenience receptacles, auxiliary contacts.

i. Instrumentation and Displays:
   1. All instrumentation readouts panel-mounted in FRP enclosures rated NEMA 4. All factory wiring. Comply with NFPA 70.
   2. Digital flow indicators for feed, product, reject, recycle.
   3. Pressure gages for inlet, cartridge filter outlet, RO feed, RO concentrate, and RO product. Refer to paragraph below.
   4. Conductivity indicator measuring product quality with digital displays, alarm relays and automatic temperature compensation.
   5. Conductivity probe mounted in the RO product.

j. Skid and Frame Assembly:
   RO machine shall be built on a skid and frame constructed of welded structural carbon steel. The entire surface shall be sand-blasted and coated with high solids epoxy coating.

E.2 pre-filter

a. Single multi-media filter sized for the RO machine inlet flow rate. Designed for suspended solids removal down to 5 microns. Automatic backwash cycle.
b. Media Tank: FRP designed for 150 psi. Pre-piped internal backwash distributor and filtered water collector.
c. Filter Media: Top layer of anthracite, middle layer of silica sand, bottom layer of multi-grade garnet. Install filter media at job site.
d. Backwash Cycle: Top-mounted, piston-operated control valve with pre-sized drain line flow control orifice. The cycle shall be initiated by and adjustable seven day electronic time clock.
e. Replacement Filter Media: Provide elements for one complete replacement.

E.3 Activated Carbon Filter

a. Single filter sized for the RO machine inlet flow rate. Designed to remove chlorine and prevent RO membrane damage.
b. Media Tank: FRP designed for 150 psi. Pre-piped internal backwash distributor and filtered water collector.
c. Filter Media: 12 x 40 mesh bituminous coal-based activated carbon. Install media at job site.

d. Backwash Cycle: Top-mounted, piston-operated control valve with pre-sized drain line flow control orifice. The cycle shall be initiated by and adjustable seven day electronic time clock.

E.4 RO Water storage tank

a. Free-standing, closed-top, flat-bottom, 500 litres total volume. Top access manway, PVC bulkhead fittings for high and low level alarm switches, RO permeate inlet, RO permeate discharge and drain. Install 0.2 micron tank vent filter at the top head. Vented to atmosphere.
b. Materials of Construction: Linear polyethylene in one piece.
c. Tank Water Level Control: Adjustable float switch that signal starting and stopping RO pump. High and low level alarm switches.

E.5 Pressure Gages

ASME B40.100, Grade A, 1% accuracy, 110 mm (4-1/2 inches) diameter, all metal case, bottom connected. White dials, black hands, graduated from 0 to 700 kPa (0 to 100 psi) and identity labeled.

E.6 Water Testing Equipment:

a. Furnish water testing equipment in a portable cabinet specially made for the installed equipment. Include sufficient materials for 6 months of normal testing procedures.
b. Silt Density Index (SDI) apparatus to measure degree of suspended solids feeding the RO membranes. Include pressure regulator, pressure gage, filter holder, 600 mL beaker, sample valve, tubing and 0.45 micron filter papers.
c. Test kit to measure total water hardness, total iron, free chlorine, pH.

E.7 Execution

a. Required Technical Services:
   Provide services of a qualified manufacturer's representative to check complete installation for conformance to manufacturer's recommendations, put system into

service, make all adjustments required for full conformance to design and specified requirements, and perform all demonstrations and tests.

b. Flushing and disinfecting:

1. Flush and disinfect new water lines and RO system and tank interiors in accordance with AWWA C651.

2. Material:

- Liquid chlorine: AWWA B301.
- Hypochlorite: AWWA B300.

E.8 Tests:

a. Operating: Tests shall be run in presence of Contracting Officers Technical Representative (COTR) or Resident Engineer (RE).

b. Procedure:

1. Operate RO system at constant maximum required capacity for one hour after demineralized RO product water is produced. When necessary, waste product water to sewer to maintain above flow rate. Product water production shall begin when a sample shows that demineralization complies with requirements.
2. Demonstrate all features of the control system including diagnostics and flow and cycle indications.

COOLING PLANT (15530)

A. General Requirements

a. Equipment shall have factory applied finish coat of machinery enamel unless otherwise specified.

b. Warranty: equipment is to carry manufacturer's warranty against defects in materials and workmanship for a period of one year after shipment.

c. Furnish equipment supplier with all necessary data such as available electric current characteristics, maximum and minimum ambient temperatures and humidities, altitude, water quality and other particular site conditions so that manufacturer will supply equipment to specifically suit Site conditions particularly for necessary derating in capacity for altitude and temperature, necessary class of insulation for electric motors, special construction for water quality, high temperatures and humidities, sandy environment etc.

d. Electric motors are to conform with the specification for electric motors given under "Electrical Works for Mechanical Systems" and with requirements given under equipment specifications for particular motor driving that equipment.

e. Equipment is shall be supplied from factory complete with all necessary accessories and components that are standard items of manufacturer or as recommended by him for good, safe and efficient operation of equipment irrespective of whether these are specified or not.

f. Pumps are shall be selected so that their operating point falls nearest to the point of maximum efficiency obtained from manufacturer's published data. Do not select pumps to operate near the end of their curve.

g. Horsepower rating of electric motors of pumps are to ensure non-overloading throughout the capacity range of pump.

h. Shop drawings for pumps: submit the following for approval, for each pump prior to shipment:

Certified performance curves showing job number, customer, customer order number, pump designation number shown on the Drawings, date of manufacture, model number, pump size, impeller diameter, impeller type, maximum impeller diameter pump can accommodate, rpm, flow- head characteristic curve, consumed horsepower curve, pump efficiency curve, cross-sectional drawing showing major components with parts numbers and parts list

Outline dimensional drawing showing overall dimensions, location of foundation bolt holes and size, location and rating of suction and discharge nozzles recommended list of spare parts installation, operation and maintenance instruction manual details and wiring diagrams of pump controllers, starters, controls or other electrical device or accessory special instructions for installation and connection of electrical device, control or accessory.

B. Air Cooled water chiller

Supply and install air cooled water chilled wherever shown on the drawings and as specified herein:

B.1 General

a. System Description
Microprocessor controlled, air-cooled liquid chiller utilizing screw compressors and low sound fans.

b. Quality Assurance
   1. Unit shall be rated in accordance with AHRI Standard 550/590 (U.S.A.) latest edition and all units shall be ASHRAE 90.1 compliant.

   2. Unit construction shall comply with ASHRAE 15 Safety Code, UL 1995, and ASME applicable codes (U.S.A. codes).

   3. Unit shall be manufactured in a facility registered to ISO 9001:2000 Manufacturing Quality Standard.

   4. Unit shall be full load run tested at the factory.

c. Delivery, Storage and Handling
   1. Unit controls shall be capable of withstanding 150 F (65.5 C) storage temperatures in the control compartment.

   2. Unit shall be stored and handled per unit manufacturer's recommendations.

B.2 Products

a. Equipment

   1. General:
      Factory assembled, single-piece chassis, air-cooled liquid chiller. Contained within the unit cabinet shall be all factory wiring, piping, controls, refrigerant charge (R-134a), and special features required prior to field start-up.

   2. Unit Cabinet:
      - Frame shall be of heavy-gage, painted galvanized steel.
      - Cabinet shall be galvanized steel casing with a baked enamel powder or pre-painted finish.
      - Cabinet shall be capable of withstanding 500-hour salt spray test in accordance with the ASTM (U.S.A.) B-117 standard.

   3. Fans:
      - Condenser fans shall be direct-driven, 9-blade airfoil cross-section, reinforced polymer construction, shrouded-axial type, and shall be statically and dynamically balanced with inherent corrosion resistance.
      - Air shall be discharged vertically upward.
      - Fans shall be protected by coated steel wire safety guards.

   4. Compressor/Compressor Assembly:
      - Comprised of semi-hermetic twin screw type compressors.
      - Compressor motor shall be direct drive, 3500 rpm, protected by motor temperature sensors, suction gas cooled motor.
      - Capacity control shall utilize an infinitely modulating slide valve to modulate capacity from 100% to 15% full load.

   5. Cooler:
      - Shall be a mechanically cleanable tubes in a shell-and-tube type cooler with removable heads.

- Tubes shall be internally enhanced seamless-copper type rolled into tube sheets.
- Shall be equipped with Victaulic-type water connections.
- Shell and cooler heads shall be insulated with 3/4-in. PVC foam (closed-cell) with a maximum K factor of 0.28.
- Design shall incorporate a minimum of 2 or 3 independent refrigerant circuits.
- Cooler shall be tested and stamped in accordance with ASME Code for a refrigerant working side pressure of 220 psig. Cooler shall have a maximum water-side pressure of 300 psig.
- Cooler shall have a cooler drain and vent.
- Low-ambient temperature protection: unit shall have factory-installed cooler heater, and pumpout cycle to protect cooler from ambient temperature freeze down to 0° F (–17.8 C).
- Cooler shall be provided with a factory-installed flow switch.

6. Condenser:
   - Coil shall be air-cooled Novation® heat exchanger technology (MCHX) and shall have a series of flat tubes containing a series of multiple, parallel flow microchannels layered between the refrigerant manifolds. Novation coils shall consist of a two-pass arrangement. Coil construction shall consist of aluminum alloys for fins, tubes, and manifolds in combination with a corrosion-resistant coating.
   - Tubes shall be cleaned, dehydrated, and sealed.
   - Assembled condenser coils shall be leak tested and pressure tested at 375 psig (2585 kPa).

7. Refrigeration Components:
   Refrigerant circuit components shall include replaceable-core filter drier, moisture indicating sight glass, electronic expansion valve, discharge service valves and liquid line service valves, and complete operating charge of both refrigerant R-134a and compressor oil.

8. Controls, Safeties, and Diagnostics:
   - Unit controls shall include the following minimum components:
     i. Microprocessor with non-volatile memory. Battery backup system shall not be accepted.
     ii. Separate terminal block for power and controls.
     iii. Separate 115-v power supply to serve all controllers, relays, and control components.
     iv. ON/OFF control switch.
     v. Replaceable solid-state controllers.
     vi. Pressure sensors installed to measure suction, oil, economizer, and discharge pressure. Thermistors installed to measure cooler entering and leaving fluid temperatures and outside air temperature.
   - Unit controls shall include the following functions:
     i. Automatic circuit lead/lag.
     ii. Capacity control based on leaving chilled fluid temperature and compensated by rate of change of return-fluid temperature with temperature set point accuracy to 0.1° F (0.05° C).
     iii. Limiting the chilled fluid temperature pulldown rate at start-up to an adjustable range of 0.2° F to 2° F (0.1 to 1.1° C) per minute to prevent excessive demand spikes at start-up.

iv. Seven-day time schedule.
v. Leaving chilled fluid temperature reset from return fluid and outside air temperature.
vi. Chilled water pump start/stop control.
vii. Chiller control for parallel chiller applications without addition of hardware modules and control panels (requires thermistors). viii. Timed maintenance scheduling to signal maintenance activities for strainer maintenance and user-defined maintenance activities.
ix. Low ambient protection to energize cooler heaters.
x. Single step demand limit control activated by remote contact closure.

• Diagnostics:
i. The control panel shall include, as standard, a display:
1) Touch screen display consisting of 1/4 VGA LCD (liquid crystal display) with adjustable contrast and backlighting.
2) Display shall allow a user to navigate through menus, select desired options and modify data. ii. Features of the display shall include:
1) Display shall be customizable and allow up to 72 data points.
2) Display shall support both local equipment or network made for remote mount.
3) Display shall allow access to configuration, maintenance, service, set point, time schedules, alarm history and status data.
4) Display shall have one button for chiller on/off.
5) Display shall include three levels of password protection against unauthorized access to configuration and maintenance information, and display set up parameters.
6) Display shall allow for easy connection of a portable hand held technician tool to access information and upload and/ or download chiller settings.
7) Display shall be compatible with the Carrier Comfort Network® (CCN) system and provide network alarm acknowledgement or indication and provide capability to fully monitor and control chiller.
8) Display alarms and parameters shall be capable of being displayed in full text.
9) Display shall be capable of displaying the last 50 alarms and will store a snapshot of a minimum of 20 status data parameters for each alarm.
10)Compressor run hours.
11)Compressor number of starts.
12)Compressor current.
13)Time of day:
– Display module, in conjunction with the microprocessor, must also be capable of displaying the output (results) of a service test. Service test shall verify operation of every switch, thermistor, fan, and compressor before chiller is started.

- Diagnostics shall include the ability to review a list of the 30 most recent alarms with clear language descriptions of the alarm event. Display of alarm codes without the ability for clear language descriptions shall be prohibited.
- An alarm history buffer shall allow the user to store no less than 30 alarm events with clear language descriptions, time and date stamp event entry.
- The chiller controller shall include multiple connection ports for communicating with the local equipment network, the Carrier Comfort Network (CCN) system and the ability to access all chiller control functions from any point on the chiller.
- The control system shall allow software upgrade without the need for new hardware modules.

• Safeties:

i. Unit shall be equipped with thermistors and all necessary components in conjunction with the control system to provide the unit with the following protections:

1) Loss of refrigerant charge.
2) Reverse rotation.
3) Low chilled fluid temperature.
4) Motor overtemperature.
5) High pressure.
6) Electrical overload.
7) Loss of phase.
8) Loss of chilled water flow.

ii. Condenser-fan motors shall have internal overcurrent protection.

9. Operating Characteristics:

- Unit shall be capable of starting and running at outdoor ambient temperatures from 32 F (0° C) to 125 F (52 C) for all sizes.
- Unit shall be capable of starting up with 95 F (35 C) entering fluid temperature to the cooler.

10.Motors:

Condenser-fan motors shall be totally enclosed, air over, single speed, 3phase type with permanently lubricated bearings and Class F insulation.

11.Electrical Requirements:

- Unit primary electrical power supply shall enter the unit at a single location (all chiller voltage/ size combinations shall have the ability to accommodate 2 power supplies to meet jobspecific requirements).
- Primary electrical power supply shall be rated to operate up to 125 F (52 C) ambient temperature.
- Unit shall operate on 3-phase power at the voltage shown in the equipment schedule.
- Control points shall be accessed through terminal block.
- Unit shall be shipped with factory control and power wiring installed.

12. Chilled Water Circuit:

- Chilled water circuit shall be rated for 300 psig (2068 kPa). Units with optional pump package are rated for 150 psig (1034 kPa) working pressure.

- Thermal dispersion proof of flow switch shall be factory installed and wired.
- Optional hydronic package (sizes 090-160):
    i. Field pipe connections shall be Victaulic type.
    ii. Optional single or primary/stand-by operation pump systems. Dual pump systems shall have a pump discharge check valve.
    iii. Pumps shall be single stage design, for installation in vertical position and capable of being serviced without disturbing piping connections.
        1) Pump casing shall be of class 30 cast iron.
        2) The impeller shall be of cast bronze, closed type, dynamically balanced, keyed to the shaft and secured by locking cap screw.
        3) The hydronic kit will be provided with a flush line connection to ensure lubrication at the seal face and allow for positive venting of the seal chamber.
        4) Each port shall be fitted with an isolation valve that allow the units to operate in parallel or standby, yet may be used to isolate one pumping unit for servicing or removal with the other pump still running.
        5) Pump shall be rated for 150 psig (1034 kPa) working pressure.
        6) The pump case shall have gage tappings at the suction and discharge nozzles and include drain ports.
        7) Dual pumps shall allow for the servicing of one pump without draining the chilled water loop.
        8) Motors shall totally enclosed 3-phase type with grease lubricated ball bearings.
        9) Each pump shall be factory tested per Hydraulic Institute Standards.
        10) Pump motors shall be VFD compatible.
    iv. Pressure/temperature taps (3) shall be factory installed to measure the pressure differential across the pump and across the strainer.
    v. Combination valve (which includes check, isolation, and modulation) shall be factory installed. Pressure/temperature taps (2) shall be factory installed to measure the pressure differential across the combination valve.
    vi. Hydronic assembly shall have factory supplied electric freeze protection to –20 F (–29 C).
    vii. Piping shall be Schedule 40 black steel.
    viii. Cast iron or ductile iron body strainer with 8 mesh screen. A factory-installed, removable fine mesh clean-out strainer for initial run period shall be included.

13. Special Features:
    Certain standard features are not applicable when the features designated by * are specified. For assistance in amending the specifications, contact your Carrier representative.
    - Low Ambient Temperature Head Pressure Control:
    - Unit shall be capable of running at outdoor ambient temperatures down to –20 F (–29 C) with the addition of antifreeze in the cooler circuit, wind baffles, and field-installed or factory-installed solid-state low ambient temperature head pressure control with condenser coil temperature sensor.

- Unit-Mounted Non-Fused Disconnect:
- Unit shall be supplied with factory-installed, lockable, non-fused electrical disconnect for main power supply.
- Optional Condenser Coil Materials:
  i. E-coated microchannel coils: E-coated aluminum microchannel coil shall have a flexible epoxy polymer coating uniformly applied to all coil external surface areas without material bridging between fins or louvers. Coating process shall ensure complete coil encapsulation, including all exposed fin edges. Ecoat shall have a thickness of 0.8 to 1.2 mil with top coat having a uniform dry film thickness from 1.0 to 2.0 mil on all external coil surface areas including fin edges. E-coated coils shall have superior hardness characteristics of 2H per ASTM D3363-00 and cross hatch adhesion of 4B-5B per ASTM D3359-02. Impact resistance shall be up to 160 in./lb (ASTM D2794-93). E-coated coil shall have superior impact resistance with no cracking, chipping, or peeling per NSF/ANSI 51-2002 Method 10.2.
  ii. Aluminum fin/copper-tube coils:
  Coil shall be constructed of seamless copper tubes mechanically bonded to aluminum fins. fins shall have wavy enhancements. These condenser coils are recommended with remote cooler applications. These coils are not recommended for corrosive environments.
  iii. Pre-coated aluminum-fin coils:
  Shall have a durable epoxy-phenolic coating to provide protection in mildly corrosive coastal environments. Coating shall be applied to the aluminum fin stock prior to the fin stamping process to create an inert barrier between the aluminum fin and copper tube. Epoxy-phenolic barrier shall minimize galvanic action between dissimilar metals.
  iv. Copper-fin coils:
  Shall be constructed of copper fins mechanically bonded to copper tubes and copper tube sheets. Galvanized steel tube sheets shall not be acceptable. A polymer strip shall prevent coil assembly from contacting sheet metal coil pan to minimize potential for galvanic corrosion between the coil and pan. All copper construction shall provide protection in moderate coastal applications.

  v. E-coated aluminum-fin coils:
  Shall have a flexible epoxy polymer coating uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation. Color shall be high gloss black with gloss — 60° of 65-90% per ASTM D523-89. Uniform dry film thickness from 0.8 to 1.2 mil on all surface areas including fin edges. Superior hardness characteristics of 2H per ASTM D3363-92A and cross hatch adhesion of 4B-5B per ASTM D3359-93. Impact resistance shall be up to 160 in./lb (ASTM D2794-93). Humidity and water immersion resistance shall be up to minimum 1000 and 250 hours respectively (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing to no less than 3000 hours salt spray per ASTM B117-90. Coil construction shall be aluminum fins mechanically bonded to copper tubes.

vi. coated copper-fin coils:

Shall have a flexible epoxy polymer coating uniformly applied to all coil surface areas without material bridging between fins. Coating process shall ensure complete coil encapsulation. Color shall be high gloss black with gloss — 60° of 65-90% per ASTM D523-89. Uniform dry film thickness from 0.8 to 1.2 mil on all surface areas including fin edges. Superior hardness characteristics of 2H per ASTM D3363-92A and cross hatch adhesion of 4B-5B per ASTM D3359-93. Impact resistance shall be up to 160 in./lb (ASTM D2794-93). Humidity and water immersion resistance shall be up to minimum 1000 and 250 hours respectively (ASTM D2247-92 and ASTM D870-92). Corrosion durability shall be confirmed through testing to no less than 3000 hours salt spray per ASTM B117-90. Coil construction shall be copper-fins mechanically bonded to copper tube sheets. Galvanized steel tube sheets shall not be acceptable. A polymer strip shall prevent coil assembly from contacting sheet metal coil pan to maintain coating integrity and minimize corrosion potential between the coil and pan. vii. Remote Enhanced Display:

Unit shall be supplied with indoor-mounted, remote, 40character per line, 16-line display panel for field installation. viii. Medium Temperature Brine (080-350 only):

Unit shall be factory modified to start and operate at leaving chilled fluid temperatures below 30 F (–1.1 C). ix. Energy Management Module:

A factory or field-installed module shall provide the following energy management capabilities: 4 to 20 mA signals for leaving fluid temperature reset, cooling set point reset or demand limit control; 2-step demand limit control (from 0% to 100%) activated by a remote contact closure; and discrete input for “Ice Done” indication for ice storage system interface.

x. Condenser Coil Trim Panels:

Unit shall be supplied with field-installed coil covers. xi.

BACnet Communication Option:

Shall provide factory installed communication capability with a BACnet MS/TP network. Allows integration with i-Vu® Open control system or a BACnet building automation system.

xii. BACnet Translator Control:

Unit shall be supplied with factory or field-installed interface between the chiller and a BACnet Local Area Network (LAN, i.e., MS/TP EIA-485). Field programming shall be required. xiii. LON Translator Control:

Unit shall be supplied with factory or fieldinstalled interface between the chiller and a Local Operating Network (LON, i.e.,

LonWorks FT-10A ANSI/EIA-709.1). Field programming shall xiv. Navigator™ hand held portable display:

1) Portable hand held display module with a minimum of 4 lines and 20 characters per line, or clear English, Spanish, Portuguese or French language.
2) Display menus shall provide clear language descriptions of all menu items, operating modes, configuration points and alarm diagnostics. Reference to factory codes shall not be accepted.
3) RJ-14 connection plug shall allow display module to be connected to factory-installed receptacle.

4) Industrial grade coiled extension cord shall allow the display module to be moved around the chiller.
5) Magnets shall hold the display module to any sheet metal panel to allow hands-free operation.
6) Display module shall have NEMA 4x housing suitable for use in outdoor environments.
7) Display shall have back light and contrast adjustment for easy viewing in bright sunlight or night conditions.
8) Raised surface buttons with positive tactile response.

xv. Touch Pilot™ display:
Unit shall be supplied with a field-installed, remote-mount, touch screen display for network attachment to the chiller.

xvi. Compressor Suction Service Valve:
Standard refrigerant discharge isolation and liquid valves enable service personnel to store the refrigerant charge in the cooler or condenser during servicing. This factory-installed option allows for further isolation of the compressor from the cooler vessel.

xvii. Suction Line Insulation:
Insulation is tubular closed-cell insulation. This option is required with the medium temperature brine option and recommended for areas of high dewpoints where condensation may be a concern.

xviii. Service Option:
The service option provides a remote service port for Navigator™ connection and a factory-installed convenience outlet that includes 4-amp GFI (ground fault interrupt) receptacle with independent fuse protection. Convenience outlet is 115-v female receptacle. Service option not available with 380 v.

xix. Remote Service Port:
Shall be a field-installed receptacle for Navigator device connection.

xx. Wye-Delta Starter:
Unit shall have a factory-installed, wye-delta start to minimize electrical inrush current.

xxi. Control Transformer:
Unit shall be supplied with a factory-installed transformer that will allow supply control circuit power from the main unit power supply.

xxii. GFI Convenience Outlet:
Shall be factory or field-installed and mounted with easily accessible 115-v female receptacle. Shall include 4 amp GFI receptacle.

xxiii. Plus-One-Pass Cooler:
Unit shall be equipped with plus-one-pass cooler heads to be used with low temperature brine options or high delta T application.

xxiv. Minus-One-Pass Cooler:
Unit shall be equipped with minus-one-pass cooler heads with reduced water-side pressure drop for series flow dual chiller control or high chilled water flow applications.

xxv. High Ambient Temperature:

Unit shall be equipped with high speed condenser fan motors to improve performance at high ambient temperatures. This option shall be required for 30XA400-500 chillers which are operating in multi-chiller configurations or have ambient temperatures at or above 100 F (37.8 C).

xxvi. Security Grilles:

Unit shall be provided with factory (or field) installed painted grilles to protect the condenser, cooler and compressor. xxvii. Upper Hail Guard:

Unit shall be equipped with a factory-installed option consisting of louvered panels on the ends of the machine which firmly fasten to the machine frame. These panels shall cover the unit from the top to the bottom of the coils, thus providing protection of the coils from hail damage.

xxviii. Full Hail Guard:

Unit shall be equipped with field-installed accessory consisting of hinged, louvered panels, which cover both ends of the unit.

This accessory provides complete protection from hail.

xxix. Full End Screen:

Unit shall be equipped with a factory-installed option consisting of louvered panels that cover the machine ends from top to bottom and firmly fasten to the machine frame. These end screens function as a privacy screen and also provide hail protection. xxx. Low Sound Package:

Unit shall be provided with sound attenuation package to include sheet metal enclosures with sound absorbing panels for each compressor.

xxxi. Remote Cooler Kit:

Allows remote installation of the cooler.

xxxii. Minimum Load Control:

Unit shall be equipped with microprocessor-controlled minimum load control that shall permit unit operation below the minimum standard operation (varies by unit size).

xxxiii. External Pump Control:

This field-installed accessory shall be required to provide control of dual, external pumps. This accessory shall not be required for single, external pumps or factory-installed pumps. xxxiv. Dual Chiller Accessory Kit:

For dual chiller applications, unit shall be provided with the additional hardware (thermistors, wells, connectors) required for proper system operation.

xxxv. Vibration Isolation (Field Mounted):

Neoprene Isolators - 1 Inch Deflection Spring Isolators: Level adjustable, spring and cage type isolators for mounting under the unit base rails.

2 Inch Deflection Seismic Isolators - Level adjustable, restrained mounts in rugged welded steel housing with vertical and horizontal limit stops. Housings shall be designed to withstand a minimum 1.0 g accelerated force in all directions to 50 mm

C. Chilled Water Pumps SET

The chilled water pumps shall be horizontal, base mounted, centrifugal, end suction pumps.

The impeller shall be made of copper alloy, statically and dynamically balanced and mounted on a stainless steel shaft.

The pump shall have mechanical seal and shall be connected to the motor with a flexible coupling.

The motor shall be a three phase squirrel cage, induction motor.

Each pump shall be guaranteed to circulate at least the nominal discharge of water under the existing head without overheating the motor of the bearings.

Each pump shall be supplied complete with all necessary accessories and mainly :

- Suction and discharge shut-off valves, discharge check valves and fittings.
- Pressure gauges and gauge cocks at both inlet and outlet.
- Strainer
- Vibration isolator mounting with flexible connections.
- Common base plate for the pump and the motor.

Pump sets shall be :

- Bolted and grouted to concrete bases.
- Aligned after being attached to bases. Alignment procedure shall provide accurate and proper angular, and concentric relationship of motor and pump shaft by use of shims tapered dowels through bolted connections.
- Have piping connections arranged so that the pump casing is not subjected to forces by the piping

The Contractor shall supply and install an electric panel board for chilled water circulating pump including:

- The main disconnecting switches
- All necessary starters and controllers with alternate operation for pumps.
- On/Off default pilot light
- Auto manual switch
- Magneto-Thermal protection for each pump.

D. Expansion tank

Supply and install expansion tank wherever shown on the drawings and as specified herein:

Closed type, including an interchangeable nitrogen bag tested to 7 bars at 110°C.

Horizontal or vertical closed vessel. One piece Butyl moduled bladder, fixed inside the vessel in one or two points. Bladder provides a complete separation between air and water, and is protected by filter. Internal and external anti-corrosion paint.

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/m^2.

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 Dimension inches	(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:

a. Metallic supports, seams, joints, bracings and fixing accessories.
b. Flexible canvas connections between ducts and air handling equipment (fans, air handlers, fan coil units, etc...).
c. Elbows, splitters, vanes and access doors as per ASHRAE or SMACNA requirements.
d. Connections and fixings to air outlets.
e. Wood frames for air outlets fixings and ducts passages through walls and slabs.
f. Insulation and/or vapour barrier wherever specified.
g. 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.

a. Flexible canvas connections shall be flame proof material, fabricated from chemically impregnated canvas.
b. 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.
c. 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:
   a. Double deflection blades for supply and return grilles and fixed blades for exhaust grilles , transfer grilles and louvers.
   b. Fixing frame for outlet mounting on walls, doors, ducts, false ceiling, etc... Frame may be of wood or metallic construction as site conditions dictate.
   c. All necessary supports and fixing accessories for concealed fixing.
   d. 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 45º 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: a.

Inverted "V" or "Y" fixed type horizontal blades.

b. Fixing frame for outlet mounting on doors on both sides. Frame may be of wood or metallic construction as site conditions dictate.

c. 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 is 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.

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 surafce 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 ½" 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/m^3 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, sheatheed 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.

Aflow 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

Apressure 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 “Sequency 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 ^{o}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 bank hummdification
- 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 :

- Effi ciency MPPS 99,95 % - EN 1822:2009 classifi cation 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 fi xing,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, heavyduty 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 vaccum 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 :	± 2° 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 + 257ºF 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 2ºF 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 gasketted 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 aftercoolers 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 aftercooler 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/m^3
- Dry Particulate 0.01mg/m^3
- Oil mist < 0.01mg/m^3
- Oil vapor < 0.03mg/m^3
- Carbon monoxide 5.0mg/m^3 5ppm v/v
- Carbon dioxide 450mg/m^3 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 flowrate 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 that 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 backup 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 he 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 are shall be shot-blasted and degreased suitable for oxygen use and cleanliness is 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 earthen wore 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 shall 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 antirotation 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 △P across terminal unit	Max ⌒P 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 antistatic 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 steal fascia soft bumper strip around bottom edge of pendants to protect personnel. The pendant should be factory assembled and fully tested before dispatch. A manufacture 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 N_2O, 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 unit 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 pressured

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 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	POLYMUTAN, 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 CHOCHESTER, FRANCE AIR, GREENHECK
24. MEDICAL GASES	MEDAES
25. BOILERS ,BURNERS ,RADIATORS	CHAPPEE , DE-DIETRICH
26. KITCHEN EQUIPMENT	SOLARCO, VRESSO, EQUIP HOTEL