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مجلس الانمـاء والاعمـار
بيــروت ـ لبنـــان

REPUBLIC OF LEBANON
COUNCIL FOR DEVELOPMENT AND RECONSTRUCTION
BEIRUT - LEBANON

CHHIM GOVERNMENTAL OFFICES BUILDING

(PHASE 2)

MECHANICAL SPECIFICATIONS
VOLUME 3 OF 5

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خطيب و علمي
شركة الاتحاد الهندسي
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CHHIM GOVERNMENTAL OFFICES BUILDING

SPECIFICATIONS FOR MECHANICAL WORKS

I N D E X

SECTION 15

PLUMBING AND MECHANICAL ENGINEERING INSTALLATIONS

SUB-SECTION 1501

GENERAL REQUIREMENTS

1.01 SCOPE OF WORKS

The works covered under this contract include the supply, installation, testing, adjusting and putting into operation systems, components of systems, and individual items of equipment, and work related thereto, in accordance with the project Tender Documents. Products not mentioned but obviously necessary to the completion of those works shall be provided.

This section applies to, and is a part of each of the following sections of the specifications as if repeated therein verbatim.

- Plumbing
- Sanitary Fixtures.
- Fire Fighting.
- Boilers
- HVAC.
- Pipes, Valves, Pumps and Accessories.
- Controls and Instruments.
- Insulation and Lagging.
- Painting.
- Tests.

1.02 RELATED WORK DESCRIBED ELSEWHERE

In addition to the sections mentioned above, refer to the following sections related to these works.

- Painting (except as specified).
- Electrical Wiring and Connecting of all Electrical Equipment.
- Excavation and Backfilling.
- Tests.

1.03 ENGINEER'S DRAWINGS

The drawings are essentially diagrammatic and include general layouts and typical details of various systems to be installed.

The Contractor shall make the installations in a workmanlike manner to conform to the structure, to avoid obstructions, to preserve headroom, and to keep openings and passageways clear without additional instruction and without additional cost to the owner.

1.04 SHOP DRAWINGS AND DATA TO BE SUBMITTED FOR APPROVAL

The Contractor shall submit shop drawings showing the exact routing and locations of all the piping, ducting, equipment, etc… all in their respective locations and according to the dimensions of the approved manufacturer. Minimum shop drawings scale shall be 1/50.

The Contractor shall submit catalog cuts and Brochures of products with reference to proper paragraph in specifications. All submittals shall be bound in one Booklet.

The Contractor shall submit adequate Engineering data on each piece of equipment together with all characteristic curves, capacity selection charts and all data for testing and balancing of the systems. In addition the Contractor shall submit manufacturer's printed installation instructions.

Moreover, contractor shall submit at this stage a detailed noise and vibration analysis study of the mechanical systems, which indicate how the specified noise and vibration criteria are met.

A specialist in the field of noise and vibration should prepare such study.

1.05 SUBSTITUTION OF MATERIALS

- All materials shall be furnished in accordance with the requirements of the Specifications.
- The naming of manufacturers in the Specifications shall not be construed as an intention to eliminate the products of other manufacturers and suppliers having approved equivalent products.
- Substitution of materials other than those named may be made upon application for approval to the Engineer.
- Materials shall be delivered in unbroken packages bearing the brand and maker's name, and shall be stored on platforms and properly covered to protect them from moisture, heat and dust.
- All materials shall be supplied from the main factories in the country of origin of the manufacturer. Any deviation from this, like supplying equipment assembled in another different country under a license or another name is not accepted unless approved by the Engineer.

1.06 CLEANING AND ADJUSTING

All apparatus shall be thoroughly cleaned before being placed in operation. Finished surfaces shall be restored if damaged and entire installation shall be delivered in perfect condition, subject to the approval of the Engineer. Systems shall be adjusted and balanced to operate as shown in the Drawings and herein specified.

1.07 **TESTS**

- All piping and equipment shall be tested as specified under the corresponding section of the Specifications and to meet local requirements. Provide anemometers, thermometers, gauges, voltmeters, ammeters, and similar instruments, not part of the permanent installation, but required to record the performance of the equipment and systems. Labor, materials, power, etc… required for testing, shall be furnished by the Contractor, unless otherwise indicated under the particular section of the Specifications.

- Tests shall be performed in the presence of representatives of the Engineer and such other parties that have legal jurisdiction and all results shall be recorded.

- In general, pressure tests shall be applied to piping systems only before connection of fixtures, equipment and appliances. In no case shall any piping, fixtures, equipment or appliances be subjected to pressures exceeding the ratings as prescribed by the manufacturers of fixtures, equipment and appliances, or accepted engineering standards for piping and fittings.

- All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Engineer and authorities having jurisdiction, and at no additional cost to the Employer.

- Any damages resulting from tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer, and at no additional cost to the Employer.

- The duration of tests shall be as determined by all parties having jurisdiction, but in no case less than the time prescribed in each division of the Specifications.

1.08 **COORDINATION OF TRADES**

The Contractor shall coordinate the work to ensure orderly, timely installations of the work of applicable trades within the various spaces indicated.

1.09 **ACCESS DOORS**

- Access doors shall provide ready access to concealed control valves, traps, cleanouts, motors, fire dampers, and other items requiring operation, adjustment, or maintenance.

- Doors and frames shall be of 12-gauge steel with invisible hinges, and cam lock fastenings. For plaster walls or ceiling, frames shall have a 50 mm wide lath plaster bond. For masonry walls, the frame shall be set flush with masonry with provisions in the jamb for anchoring. Doors shall be solid flush steel with gray metal primer. Location of access doors shall be coordinated with and shall have the approval of the Engineer before the mechanical work is installed.

1.10 SIGN AND ACCESSORY FASTENING

- Warning and instruction signs, wherever specified or otherwise required, shall be securely fastened where shown or directed with bolting anchors herein specified for masonry construction or round head chrome plated brass wood screws and washers for wood construction. Signs shall not be hung loose on chains or by any other method wherein the sign will be free to move. Sign shall be installed in a conspicuous well lighted location adjacent to the equipment it refers to and shall be easily read by occupants in standing position on floor.

- All accessories such as wrenches specified to be hung on chain adjacent to the equipment they serve, shall be arranged for stowing in a rigid manner and shall not be hung loose, or otherwise, that may permit the chain or wrench to move or rattle.

1.11 VALVE CHART LOCATIONS

Valve charts shall be provided for each piping system and shall consist of schematic Drawings of piping layouts, showing and identifying each valve and describing its function. Two copies of each chart, sealed to rigid backboard with clear lacquer placed under glass and framed, shall be mounted in the building as directed by the Engineer.

1.12 PERMITS

The Contractor shall obtain and pay for all necessary permits, inspections and tests, for the proper installation of his work, as may be required by the various administrative authorities having jurisdiction.

Certificates of inspections, tests, etc., with the proper approval certified thereon, shall be secured by the Contractor and these documents shall be delivered to the Engineer before the work in question will be accepted.

1.13 OPENING IN EXTERIOR WALLS

Openings in exterior walls, particularly at or below grade shall be kept properly plugged and caulked at all times, (expect when being worked on) to prelude the possibility of flooding due to storms or other causes. After completion of work, openings shall be permanently sealed and caulked in the manner herein specified.

1.14 NAMEPLATES

Each unit of equipment shall be identified by a permanently attached nameplate made of brass or other corrosion-resistant metal. Plates shall be not less than forty (40) by eighty (80) mm. Plates shall bear information pertaining to the unit as follows:

- System and unit designation from schedule of equipment.
- Manufacturer's name and address.
- Serial and model number.
- Rated capacity.
- Temperature, pressure or other limitations.

All controls shall have attached or mounted adjacent thereto, a nameplate indicating which equipment it controls. These nameplates shall be black surface, white core laminated "Bakelite" with incised letters. Nomenclature shall be in accordance with a schedule approved by the Engineer.

1.15 INSTRUCTION MANUAL

The Contractor shall furnish and submit to the Engineer in triplicate bound, A4 size, Instruction Manuals containing the following material:

* Brief description of each system and its service and basic operation features.
* Manufacturer's mechanical equipment parts list of all functional components of the systems listed on the Drawings, control diagrams and wiring diagrams of controllers. List shall give system No., unit no., Manufacturer's Model No., and Manufacture's Drawing no. Parts list shall include manufacturer's recommended spare parts for one year operation.
* Chart of the tag numbers, location and function of each valve.
* Maintenance instructions for each type of equipment.
* Possible breakdowns and repairs for each type of equipment.
* List of nearest local suppliers for all equipment.
* Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.
* Complete, as installed, color coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.
  The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

  All items shall be available at least four weeks prior to the substantial completion date.

1.16 PIPING SYSTEM IDENTIFICATION

a) Legend

The material in piping system shall be identified. Primary identification should be by means of a lettered legend naming the material conveyed by the piping in full or abbreviated form. Arrows shall be used to indicate the direction of flow.

The legend shall be brief, informative, pointed, and simple Legends shall be applied close to valves and adjacent to changes in direction, branches, where pipes pass through walls or floors and as frequently as needed along straight runs to provide clear and positive indication. Identification maybe applied by stenciling, tape or markers.

Pipe marking should be highly visible

b) **Type and Size of Letters**

Outside diameter of pipe or covering (inch)	Length of color field (inches)	Height of letter (inches)
1/2 " to 1 1/4 "	8	1/2"
1 1/2 " to 2 "	8	3/4"
2 1/2 " to 6 "	12	1 1/4"
8 " to 10 "	24	2 1/2"
Over 10 "	32	4"

c) **Color**

Color should be shown on the piping, but in combination with a legend.

d) **Color Code Indication for Service Pipelines**

	Basic color	Letters
Water Supply	Green	Blue
Drainage	Yellow	Black
Heating	White	Green
Fuel oil	Brown	Crimson

1.17 INSTRUCTION PERIOD

- The Contractor shall furnish the services of the control manufacturer (or his representative) to train or instruct the Employer's Representative for a period of five (5) eight (8) hour days. This period shall follow the final inspection date, and shall be divided into two (2) equal or unequal periods if so requested by Employer.
- The contractor shall be responsible for the training and familiarization of the employer's maintenance staff for a period of at least two weeks on all equipment and plants he has supplied or installed.

1.18 TRENCH BOTTOM GRADING

- All trench bottom grading required for plumbing work shall be done under the requirements of this section of the Specifications. The bottom of all trenches shall be trimmed by hand method to receive pipes at their respective finish levels. Trenches shall not be excavated by machine below levels as above specified.
- After the pipelines have been tested and approved, backfill shall be compacted thoroughly by hand tampers below centerlines of pipes and to at least 300 mm above it. No backfill shall be placed in such a manner as to cause damage or misalignment to the pipes or protective coating if used. Backfill material under such conditions shall be earth, 20 mm crushed stone or gravel above the top of piping and hubs.

1.19 ELECTRICAL WORKS

A) General

- All electrical works and materials supplied and installed under this Section of the Specifications shall conform, in all respect, to the requirements of the Electrical Specifications.
- All electrical wires, cables and conduits shall be as specified in the Electrical Specifications.

B) Scope of Work

- The following electrical works and materials shall be supplied and installed under this Section of the Specifications.
  - All electrical equipment, wiring, cables, metal boxes, cable boxes, conduits, earth connections, control panels, push buttons, starters, disconnect switches, contactors, circuit breakers, switches, relays, protective equipment and all other electrical equipment which are necessary for the satisfactory operation, control and protection of all Plant supplied under this Section of the Specifications, unless otherwise specified.
  - In the Pump Room, air-handler's rooms and wherever shown on the Mechanical and/or the Electrical Drawings where a number of starters controllers, instruments, indicating lights and the like occurs, they shall be arranged in a central position in a neat, easily cleaned, factory-built panel, or motor control center assembly. The assembly shall include isolators and all necessary fuses, busbars, starters, instruments, relays, push-buttons, indicating lights and the like. Components shall be mounted in a logical order based on the sequence of operation.
  - Starters, control gears, wiring, switch fuses, contactors, circuit breakers, bus-bars, and the like, for motors supplied under another Section of the Specifications but included on motor control centers or panels used for this Section in accordance with Electrical Schedules and Drawings.
  - Isolating devices, when not provided with electrical equipment furnished under another Section of the Specifications, shall be provided and installed under this Section of the Specifications, and in compliance with the Electrical Specifications.
  - Final connections between nearby power outlets or disconnect switches and mechanical equipment shall be made with metallic flexible conduits.

1.20 SPARE PARTS

- The contractor shall submit a priced list of spare parts for all the equipment supplied sufficient for five years of operation all in accordance with the recommendations of the manufacturers of the equipment.

1.21 MACHINERY

All moving parts of machinery shall be protected by strong guards to adequately protect all personnel working on or in the vicinity of the equipment.

Wherever possible, moving parts should be protected by guards supplied by the equipment manufacturer. All guards must be strongly attached to equipment and should be designed to be easily removed for access, servicing, adjustment and maintenance.

1.22 MAINTENANCE KIT

The Contractor shall provide a complete maintenance Kit consisting of a full set of tools suitable for erection of all components of the plant including the electrical equipment. The full list of the tools shall be submitted by the tenderer in his offer.

1.23 "AS-BUILT" DRAWINGS

All drawings, where required, shall be corrected by the Contractor and submitted to the Engineer for approval as the Works, proceed. Upon the completion of the Works, the Contractor shall prepare a completely new set of Drawings for the project as executed and submit them in duplicate to the Engineer for approval. When approved by the Engineer, the Contractor shall submit one C.D and six copies of all Drawings duly marked "As-Built". The final payment shall not be made except for the actual works that have been completed in accordance with the specifications and have been duly presented on the "As-Built Drawings".

The Contactor shall not be entitled to any extra payment or extension of time for the correction, preparation and supplying of the mentioned drawings and C.D.

1.24 ABBREVIATIONS

The following abbreviations have been mentioned in the specifications.

- AGA : American Gas Association.
- AMCA : Air Moving and Conditioning Associations.
- ANSI : American National Standard Institute.
- ARI : Air Conditioning and Refrigeration Institute.
- ASA : Acoustical Society of America.
- ASHRAE : American Society of Heating Refrigeration and Air Conditioning Engineers.
- ASME : American Society of Mechanical Engineers.
- AWWA : American Water Works Association.

- NFPA : National Fire Protection Association.
- NPC : National Plumbing Code.
- SMACNA : Sheet Metal and Air Conditioning Contractors National Association.
- UPC : Uniform Plumbing Code.
- UL : Under Writers Laboratories.
- BTU : British Thermal Units.

SUB-SECTION 1502

PLUMBING

1.01 SANITARY AND STORM DRAINAGE

A) Description of Work

The Sanitary and Storm Drainage Systems consist of sanitary drainage, fixtures, fittings, piping and equipment as hereinafter specified and as shown on the Drawings. The sanitary drains shall be carried to appropriate manholes shown on the Drawings and shall be connected to the Public Sewer Network.

Storm water shall be drained by means of roof drains and leaders as show on the Drawings.

B) General Requirements

- All horizontal soil and waste piping shall be installed with a slope of not less than one percent (1%) unless otherwise specified and/or noted on the Drawings.
- All plumbing fixtures shall be adequately trapped and vented. Rough in and install fixtures at height as recommended by manufacturer unless otherwise indicated.
- Vent piping shall not be trapped and shall be graded to drip back to waste or soil line.
- All storm drainage piping below grade shall be installed immediately after excavation and pipes shall be laid so that entire length bears on firm soil. Excavate for pipes and do not backfill until installation has been tested.
- All storm drainage piping above grade shall have a slope of two percent (2%) where possible; the minimum acceptable is one percent (1%).
- Changes in direction of piping shall be generally made with long radius fittings.
- Floor drains subject to evaporation shall have a water seal of 125 mm.
- Floor drains shall be clamped to flashing or to water proofing membrane. Clamping collars shall be supplied with drains only where flashing is required.
- All floor drains shall be set 3 mm. below the normal finished floor, with a gradual pitch extending away from the drain, unless otherwise noted on Architectural Drawings.
- All pipes and fittings shall be kept clean, with the exposed ends of uncompleted or unconnected work plugged.

- Cleanouts shall be placed at all changes in directions, at bends, at ends of soil, waste, sewer and as shown on drawings with a maximum spacing of 15 m. on straight runs inside building.

- Fire-Stops shall be provided, where required, at all Wall/Floor penetrations of Plastic Pipes.

- All work done under this section shall be in accordance with the National Plumbing Code Handbook and Uniform Plumbing Code unless otherwise specified.

- All pipes at ceiling level of generator room shall be cast iron.

- All exposed drain pipes in basements shall be cast iron.

C) **Tests**

- When the roughing-in work is completed and before connection of fixtures, the entire system shall be subjected to thorough flushing and then to a water test by plugging up all openings and filling all of the lines to the roof level. Any defects shall be corrected, at the expense of the Contractor.

- Tests shall be performed in the presence of the parties having jurisdiction and the Engineer, and all results shall be recorded.

1.02 **MISCELLANEOUS ITEMS**

A) **PVC Floor Drains**

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

Each floor drain shall be of the UPVC construction with 50 mm water seal.

Drain shall have white polypropylene or chrome plated removable square tile with circular grid strainer. 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.

Drain shall be fitted with 1" (25mm) access plug for cleaning purposes.

B) **PVC Roof Drains**

Supply and install all roof drains wherever shown on the Drawings and as specified hereinafter.

Each drain shall be of UPVC with no trap, having large sump, integral flange and dome type polypropylene strainer.

C) **PVC Garage Drains**

Supply and install all garage drains wherever shown on the Drawings and as specified hereinafter.

Each drain shall be of polypropylene with bucket, adjustable height, and heavy duty ductile iron grating suitable for 2.5-ton car loading.

D) **PVC Trench Drains**

Supply and install all trench drains wherever shown on the Drawings and as specified hereinafter.

Each drain shall be of UPVC with no trap, having large sump, integral flange and flat polypropylene strainer.

E) **Cleanouts**

Supply and install cleanouts wherever shown on the Drawings and of sizes as detailed on the Drawings.

Each cleanout shall be of the same material and dimensions as the pipe to be cleaned, and shall be placed at ceiling level, in walls, or slabs, as need be, for ease of operation.

Ceiling pipe cleanouts on cast iron pipes shall be cast iron with straight body for caulking into soil pipe hub and fitted with bronze counter sunk plug; same size as soil pipe.

Floor and ceiling pipe cleanouts on PVC pipes shall be UPVC access plugs with UPVC screw caps.

F) **PVC Roof Vent Caps**

Supply and install vent caps on all vent stacks at the highest level of the stack and wherever shown on the Drawings.

Each vent cap shall be of UPVC with open slots all around cowl and shall be cemented onto the stack vent pipe at least 150 cm above roof level.

G) **Trench Grate & Frame**

Supply and install wherever shown on drawings trench grates and frames as hereinafter specified.

Grate shall be cast iron, heavy rectangular, sectional bar pattern, suitable for heavy traffic. Grate openings shall be laid in wide dimensions in a steel frame with flat bar anchors and nailing clips.

H) **Approved Manufacturers**

Except where otherwise specified, approved manufacturers for items under this section shall be:

- Zurn Industries Inc.
- Josam Mfg. Co.
- Terrain Plastics.
- Hepworth Plastics.
- Pont -A- Mousson.

or approved equal.

1.03 **SITE DRAINAGE**

A) **General**

The Site Drainage shall consist of site sanitary drainage complete with piping, manholes, and all ancillaries as deemed necessary and as shown on the Drawings.

B) **General Requirements**

- Connections to manholes, and catch basins, shall be watertight after installation.
- All piping shall conform accurately to the lines and grades shown on the Drawings.
- Any connections for existing systems shall be made with a minimum amount of disturbance to the existing lines.
- Any existing pipelines or structures, which are damaged while making connections, shall be replaced or reconstructed to the satisfaction of the Engineer without cost to the Employer.
- All piping shall be examined for defects. Any defective piece discovered after installation and test shall be removed and replaced by the Contractor at no expense to the Employer.
- System shall be inspected and joints approved before any backfilling is placed over pipes.
- All pipe and fittings shall be kept clean until final acceptance of work. The exposed ends of all uncompleted lines shall be closed with wooden plugs adequately secured at all times when pipe laying is not actually in progress.

- All piping shall be installed on a good foundation and adequate means taken to prevent settlement.

- The Contractor shall trim the bottom of trenches to receive the pipes and shall round out bottoms so that the pipe will rest firmly on 200 mm. undisturbed sand at proper line and grade.

- All piping laid in trenches shall be provided with a solid uniform bearing throughout the entire length.

- Trenches shall be kept free from water by pumping, use of well points, underdrains or other approved means during pipe laying operations so that all pipe joints are made in dry areas.

- Precautions shall be taken to protect incomplete work from flooding due to storms or other causes. All pipe lines or structures not stable against uplift during construction shall be thoroughly braced or otherwise protected.

- All work under this section shall conform to the requirements of the National Plumbing Code Handbook, and Uniform Plumbing Code, unless otherwise specified hereinafter.

C) **Tests**

- If an inspection of the completed sewer or any part thereof shows any structures, pipes or joints, which are defective, the defective work shall be replaced or repaired immediately and to the satisfaction of the Engineer.

- The Contractor shall perform, at his own expense, any tests or inspections required by local authorities. The Engineer shall witness the tests.

- All joints shall be inspected and an inspection of the line as a whole shall show pipes to be true to line and grade with full circles visible at all manholes.

D) **Manholes**

- Manholes shall have the minimum inside dimensions shown on the Drawings.

- Manhole walls shall be of poured-in-place reinforced concrete. Top section must be cast such as to suit elevation and accommodate size of manhole frame and cover.

- Manhole floor shall be of reinforced concrete and inverts stream lined with cement and mortar into a semi-circular path with sanitary turns and have their corners filled and sloped towards the water path to prevent any settlements of solids as detailed on the Drawings.

- Concrete foundation mattes for manholes shall be constructed in accordance with details as shown on the Drawings.

- All pipes or castings to be embedded in the manhole walls shall be accurately set, and if so required, headers shall be laid round the casting so embedded.

- All work must be carried out in a manner to ensure watertight work, and any leaks shall be caulked, repaired, or the entire work shall be removed and rebuilt. Attention is particularly called to the necessity of keeping the water level below all parts of the foundation and walls until the cement has obtained adequate setting.

E) **Frames, Covers & Gratings**

- The Contractor shall furnish and set level and to the proper grade, a cast iron frame and cover or frame and grating of the form and dimensions shown on the Drawings. The concrete masonry shall be neatly and accurately brought to the dimensions of the base of the frame. The frames shall be thoroughly embedded in mortar. All covers and frames shall be heavy-duty quality.

- All castings for frames, covers, and gratings shall be of tough gray iron. All castings shall be made accurately to dimensions and shall be machined to provide even bearing surfaces. Covers and gratings must fit the frames in any position and if found to rattle under traffic, shall be replaced. Filling to obtain tight covers will not be permitted. No plugging, burning-in or filling will be allowed. All castings shall be carefully coated inside and out with coal tar pitch varnish of approved quality.

F) **Excavation and Backfilling for Pipe Laying**

- The laying of pipe underground will require trimming and grading of trench bottoms for pipes and will require backfilling with approved materials and tamping around all pipes to center line of pipes as the pipe laying progresses to provide protection and stability for the piping. Pipe laying work shall be conducted so that trenching operations are not advanced too far ahead of pipe laying operations resulting in excessive lengths of open trenches.

  The pipe shall not be laid in water or when the trench or weather conditions are unsuitable for such work.

- The Contractor shall trim the bottom of all trenches to receive pipes and shall provide grade finish by hand methods. The bottoms of all trenches shall be rounded so that, in so far as practical at least one-third of the circumference of the pipe will rest firmly on 200 mm. of undisturbed sand at proper line and grade. Bell holes, where required, shall be dug to ensure pipe resting for its entire length upon the bottom of the trench. Trenches shall not be excavated below grade by machine.

- After pipes have been tested and approved, trenches shall be backfilled with approved materials carefully deposited in layers not to exceed 150 mm. in thickness on both sides, and thoroughly and carefully tamped. Backfilling and tamping in layers of 150 mm. shall be continued until a depth of 300 mm. has been placed over the pipe. Backfill around the pipes to a depth of 150 mm. over the pipes shall be clean sand. No backfill shall be placed in a manner such as to cause injury to the pipe. Where pipe crossings occur, the lower pipe shall be laid first and

the backfill thoroughly compacted to the level of laying the higher pipe. Backfill materials under such conditions shall be earth, approved gravel or concrete as directed.

Care should be taken to provide adequate cover before using power compactors or heavy rollers.

All pipes running under roads and all pipes with a cover of less than one meter, should be protected by laying concrete or precast concrete slab over the bedding.

G) **Approved Manufacturers**

Except where otherwise specified, manufacturers for items under this division shall be:

Frames, Cover & Gratings

- Broads Manufacturing Co.
- Zurn Industries Co.
- Elkington Grating Covers and Frames (The Dover Engineering Works Limited) or approved equal.

1.04 WATER SUPPLY SYSTEM

A) **General Description**

Water is supplied from Municipality water main through a water meter and stored in under ground reservoirs as indicated on Drawings.

The Water Supply System shall consist of piping, valves, pumps, automatic controls, tanks, electric water heaters, and all equipment as hereinafter specified and shown on the Drawings.

B) **General Requirements**

- Automatic air vents shall be installed at all air pocket locations, and at the highest points in the lines (when specified).

- Gate valves shall be installed at the base of each riser line, each branch main and on each lateral branch to fixtures or equipment and where shown on the Drawings.

- Drain valves with threaded hose connections shall be provided at all low points of the piping system.

- All work done under this section shall be in accordance with the National Plumbing Code Handbook or Uniform Plumbing Code unless otherwise specified.

- The minimum pipe size to be used is 3/4" (20mm) diameter.

- All electrically operated equipment, specified under this section, (like electric water coolers, heaters ... etc.) shall be provided with the necessary length of electrical cord (including ground conductor), with appropriate plug suitable for connection to the electrical outlet.

C) **Tests**

- All piping shall be tested as per the specifications under the section "TESTS".
- The hot water system shall be tested for satisfactory circulation to assure water within the required temperature limits at all points.
- Additional tests shall be made as may be required by local authorities, or as directed by the Engineer.

D) **Water Service Main**

The Contractor shall connect the water service line from the public main, in the vicinity of the building low level water reservoirs.

E) **Hose Bibs**

Hose bibs shall be finished 3/4" (20mm) red brass, compression type with four arm cross metal handle and standard 3/4" (20mm) male hose connection except in toilet rooms and where ever indicated on the drawings they shall be polished chrome plated.

F) **Polyethylene Water Tanks**

Cylindrical water tanks shall be molded in one- piece seamless construction by rotational molding. The tanks are designed for above- ground and are capable of containing water at atmospheric pressure.

The material used shall be virgin polyethylene resin as compounded and certified by the manufacturer.

All polyethylene resin material shall contain a minimum of a U.V. 8 stabilizer as compounded by the resin manufacturer. Pigments may be added at the purchaser's request, but shall not exceed 0.25% (dry blended) of the total weight.

The standard design specific gravity shall be not less than 1.5.

The minimum required wall thickness for the cylinder straight shell must be sufficient to support its own weight in an upright position without any external support.

Flat areas shall be provided to allow locating large fittings on the cylinder straight shell.

The top head must be integrally molded with the cylinder shell. The minimum thickness of the top head shall be equal to the top of the straight wall.

The hydrostatic water test shall consist of filling the tank to brim full capacity for a minimum of four hours and conducting a visual inspection for leaks.

The finished tank wall shall be free, as commercially practicable, of visual defects such as foreign inclusions, air bubbles, pinholes, pimples, crazing, cracking and delimitations.

All cut edges where openings are cut into the tanks shall be trimmed smooth.

G) Electric Water Heaters (Storage Type)

Supply and install electric water heaters wherever shown on the drawings of capacities as indicated on the drawings.

Each electric water heater shall be of the cylindrical storage type constructed of heavy gauge steel with white enamel finish and glass lining from inside.

Heater shall have polyurethane foam insulation wall between the outer casing and the glass lining all around top and bottom of cylinder. Heater shall be suitable for a working pressure of 100 psi (690 Kpa)

Each electric water heater shall be complete with the following:

- Fast acting surface mounted thermostat for automatic temperature control.
- Factory installed sensitive high limit energy cut-off (for safety to prevent overheating) present at 210 ^{O}F (99 ^{O}C) .
- Electric element of 3000 watt capacity and smaller as indicated on the drawings. Element shall be constructed of highest quality resistance wire sheathed in mineral filling and the whole encased in a copper tube and subjected to a high voltage test.
- A non-return valve at the cold water inlet to the heater.
- Pressure relief valve installed between heater and non-return valve and shall be listed by AGA and shall be labeled by AGA or ASME.
- Removable access panel to the heating element and thermostat.
- Factory installed nipples.
- Chrome plated gate valves at inlet and outlet of heater.
- Wall fixing brackets and support.

Approved Manufacturers:

- Patterson Kelly co.
- A.O. Smith
- Mor-Flo
- Rheem

or approved equal.

H) **Shock Arrestor**

- Shock arrestor shall be mechanical pneumatic type, stainless steel construction with hermatically sealed bellows, and threaded connection.
- Arrestors shall be located adjacent to all quick closing valves, solenoid valves, where required and as indicated on Drawings.
- Proper sizes shall be determined by the individual application.

I) **Water Meter**

A water meter, all bronze construction type, shall be supplied and installed by the Contractor. The water meter shall be a disk positive displacement type and shall be furnished with a straight reading dial and shall have a rated maximum delivery of not less than twice the flowing GPM (l/s).

J) **Pipe Expansion Joints**

Expansion joints shall be installed whenever pipes cross a structural expansion joint. Pipe expansion joints shall be of the bellows type with flanged ends and stainless steel bellows suitable for the specified working pressure of the system.

Expansion joints shall be provided with guides to prevent any unnecessary misalignment of the pipe. Guides and anchor arrangements shall be as per the recommendations of the expansion joints manufacturers.

K) **Approved Manufacturers**

Except where otherwise specified, manufacturers for items under this chapter shall be:

- Water Meters
  - Badger Meters, Inc.
  - Bailey Meters
- Automatic Controls
  - Honeywell
  - Barber Colman
  - ITT

or approved equal.

SUB-SECTION 1503

SANITARY FIXTURES

1.01 GENERAL DESCRIPTION

The Sanitary Fixtures Work shall consist of installing, testing and putting in operation all Sanitary Fixtures, accessories, pipe fittings and equipment as hereinafter specified and as shown on the Drawings.

1.02 GENERAL REQUIREMENTS

- All fixtures and trimmings, insofar as practicable, shall be of one manufacture.
- Ample application of petroleum jelly shall be made to all surfaces of exposed chrome plated piping, valves and fittings immediately after installation.
- All fixtures shall be set straight and true.
- Concealed brackets, hangers and plates shall have a shop coat of paint.
- All exposed piping and trim shall be chrome plated and fully protected during installation. Strap or padded wrenches shall be used on chrome plated pipe fittings and valves.

1.03 SANITARY FIXTURES

- Sanitary fixtures shall be complete with all required trimming, including mixers, waste plugs, traps, supplies, stop valves, escutcheons, casings and all necessary hangers, plates, brackets, anchors and supports.
- All Fixtures and Accessories shall be of the water-conserving type.
- Vitreous china fixtures shall be of first quality with smooth glazed surfaces, free from warp, cracks, checks, discolorations or other imperfections.
- Enameled cast iron fixtures shall be of acid-resisting type.
- In the selection of sanitary fixtures and their accessories, model numbers of certain manufacturers catalogues are given to describe the type, shape and quality of the items requested and does not in any way limit the supply to the model listed.
- Any item of different make judged by the Engineer to be similar in quality and manufacture will be approved.

1.04 EXPOSED PIPING AND TRIM IN TOILET AREAS

All piping, valves and fittings exposed to view shall be screwed, polished, chrome plated brass. Plating shall be accomplished after threading.

1.05 FIXTURE SETTING

Fixtures shall be set in a neat, finished and uniform manner making the connections to all fixtures at right angles to the wall, unless otherwise directed by the Engineer.

Roughing for this work must be accurately laid out so as to conform to finished wall material. Fixtures are not to be set until so directed by the Engineer.

The location and disposition of all items shall be as indicated on the relevant drawings.

All fixtures and fittings shall be as detailed in the schedule of fixtures, indicated on the drawings.

1.06 WESTERN WATER CLOSET

Western water closets shall be made of vitreous china, siphon jet, floor mounted.

Western water closets shall be provided with built-in "S" trap, plastic seat, brass holding bolts, washers, nuts, and china caps.

The spray assembly unit (BPH) shall consist of a flexible hose, nozzle with aerator, mounting bracket, exposed vacuum breaker and self-closing push-button valve. All toilets shall be complete with flush valves.

The closets shall be provided with seats of smooth non- absorbent material.

Western water closet shall be provided with vitreous china semi recessed toilet paper holder.

1.08 WALL HUNG TYPE LAVATORY

Wall hung type made of vitreous china, punched for concealed wall hangers, with tap holes center-set with spray spout.

Lavatory basins shall be supplied with fixtures with handle stops, and "P" traps made of chrome-plated cast brass or approved equal material with cleanout plug. Strainer shall be made of copper alloy or corrosion-resistant steel. Taps shall have replaceable seats and the stem of valve disc shall rotate onto the seat.

Lavatory shall be provided with vitreous china shelf, Vitreous China pedestal, semi recessed soap holder, crystal glass mirror and towel holder.

1.09 COUNTER TOP LAVATORY

Counter top lavatory basins made of vitreous china, Oval type with splash-lip overflow, and tap holes center set.

1.11 JANITORS SINKS

Sinks shall be of enameled fire clay complete with:

- P Trap.
- Two 15mm diameter taps (chrome plated)
- 40mm diameter grid waste
- Stainless steel hinged bucket grating
- 305mm high legs with supports to wall

1.12 KITCHEN SINKS

Sinks shall be single or double compartment, made of stainless steel, enameled cast iron, enameled steel or of stoneware. Sinks shall be provided with the following:

- Mounting flange
- Combination sink tap set-set with swing spout with vacuum breaker. All parts shall be chrome-plated.
- Strainer with brass body and rubber stoppers or open strainer, basket and tailpiece, and a cast brass P- trap. All parts shall be chrome plated.

Kitchen sinks shall be provided with drain boards. Underside of compartment and drain board shall be undercoated when made of cast iron or steel.

Stainless steel sinks shall be of satin finish with undersides undercoated for sound dampening. Compartments and tap deck shall be recessed below outside edge of sink. The mixer shall be provided with a gooseneck swing spout and aerator mounted on common deck base. The waste fitting shall be of the duo strainer type complete with a conical basket. Sinks shall be provided with vitreous china semi recessed soap and sponge holder.

1.13 EXECUTION

A) Fixture Joints

Joints shall be standard fittings furnished with the fixtures. Where space conditions will not permit standard fittings, special short-radius fittings shall be provided.

The fixture joints on soil pipes shall be made absolutely gastight and watertight.

B) **Strainers and Fixture Outlets**

Lavatory basins shall have waste outlets not less than 30mm in diameter. Wastes may have open strainers or may be provided with stoppers.

Sinks shall be provided with waste outlets not less than 40mm in diameter. Waste outlets shall have open strainers or shall be provided with stoppers.

C) **Fixture Supports**

Wall hung plumbing fixtures not supported on chair carriers shall be supported on wall hangers or screw bolts furnished with the fixtures.

Where appearance of the bolts is not objectionable, the fixture shall be fastened to the wall by through-joint bolts. Bolt heads or nuts shall be hexagonal and painted or chromium-plated, and washers shall be painted or chromium-plated to match bolt heads or nuts.

Where appearance of bolt heads or nuts is objectionable, fixtures shall be fastened to walls by machine-bolt expansion shields or stud-type expansion bolts.

D) **Fixture Traps**

Sanitary fixtures, excepting those having integral traps, shall be separately trapped by a water-seal trap, placed as close to the fixture outlet as possible.

The trap shall be of the same diameter as the fixture drain to which it is connected.

A trap integral with the fixture shall have a uniform interior and smooth waterway.

Each fixture trap shall have a water seal of not less than 60mm.

Each fixture trap, except those integral or in combination with fixtures in which the trap seal is readily accessible or except when a portion of the trap is readily removable for cleaning purposes, shall have an accessible brass trap- screw of ample size.

Cleanouts on the seal of a trap shall be made tight with threaded element plug and approved washer.

No fixture shall be double trapped.

1.14 APPROVED MANUFACTURERS

Except where otherwise specified, approved manufacturers for items under this Section shall be:

- Sanitary Fixtures
  - * American Standard
  - * Ideal Standard
  - * Armitage Shanks
  - * Twyfords
  - * Villoroy & Boch
  - * Kohler

- Fittings and Mixers
  - * Ideal Standard
  - * Grohe
  - * Kohler
  - * Crane

- Stainless Steel Sinks
  - * Frankee
  - * Elkay
  - * Armitage Shanks

- Accessories
  - * Bebeck

or approved equal.

SUB-SECTION 1504

FIRE FIGHTING SYSTEM

1.01 GENERAL DESCRIPTION

- Supply and install, wherever shown on the Drawings fire fighting system consisting of Portable Fire Extinguishers.

1.02 PORTABLE FIRE EXTINGUISHERS

- Supply and install wherever shown on the drawings portable fire extinguishers of the capacities and ratings indicated on the drawings.

- Each unit shall be complete with a frame for hanging, to the wall, 36 cm long hose, discharge valve and pressure gauge.

- Extinguisher shall be rechargeable dry chemical type or CO2 type.

- Approved Manufacturers:

  - Walter Kidde
  - Fyr Fyter
  - Read and Campbell
  - Preussag

or approved equal.

SUB-SECTION 1505

BOILERS

1.01 HOT WATER BOILERS

A. BOILER PACKAGE

Supply, Deliver and Install where indicated, Boiler - Burner Package/s completely integrated, self-contained, fully automatic units.

Each unit shall consist of a fire-tube boiler, mounted on skid or integral steel frame, equipped with a complete forced draft burner assembly, and controls.

All refractories for boiler and burner shall be factory installed.

Each unit shall be provided with full trimmings, controls and accessories, attached to the unit at the Factory and fully inspected and fire-tested at the factory before shipment, as detailed elsewhere.

Each complete package shall be supplied fully assembled and piped ready for connection of water, gas and electrical, to be operational.

Each unit shall have a capacity as indicated in the capacity schedule. The Boiler-Burner Package /s shall be the product of one manufacturer.

B. BOILER CAPACITY AND RATINGS

Type: Horizontal Tubular, Forced Draft, Fire Tube, Multi-pass, Dry-Back, Packaged steel welded construction

Use: Hot Water

Firing Mode

This shall be full on-off, Hi-Lo firing with enforced and guaranteed Lo-Fire Start. The turn down ratio shall be not less than (4:1).

Efficiency

This shall be guaranteed by the Manufacturer to be not less than 85% over the complete range. The Efficiency shall be computed as per the A.P.I Standards using the Gross Calorific Value (Higher Calorific Value). Efficiency computed with the Lower Calorific values (giving higher figures) shall not be considered.

C. **BOILER CODES, APPROVALS, CERTIFIED REPORTS**

The Boiler shall be constructed in accordance with the ASME Boiler Code, and must be tested and receive boiler inspection and approvals prior to shipment, by an authorized Inspector from the National Board.

The boiler shall be completely pre-assembled and fire-tested at the factory. It shall be fire-tested and controls set as for normal operation.

All readings shall be consigned in an official Factory Fire-test Report.

The factory fire-test report shall be supplied to the Purchaser, along with the standard Boiler literature supplied such as Manuals, Brochures, etc… detailed elsewhere. The report shall be made available to any Agency authorized, if so desired by the Customer.

This test may be witnessed by the Purchaser or Purchaser's Representative if desired.

D. **TECHNICAL MANUALS , DRAWINGS, TESTS AND START-UP, DELIVERY AND TRAINING OF PERSONNEL**

Technical Manuals

The Manufacturer shall supply 3 sets of Boiler Technical literature comprising:

- Start-up and Operating Instructions
- Boiler Service and Spare Parts Manuals
- Burner Service and Spare Parts Manuals
- Installation Instructions
- Wiring Diagrams, (Boiler control Panel)
- Factory Fire-Test Reports, Boiler Production Data Report, conforming to ASME Code.
- Submittal: Manufacturer shall submit a complete booklet containing shop drawings as listed below, together with catalogues and Brochures of major components.

  Fabrication shall not commence until the Submittal has been approved.

Drawings

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 to site contingencies.

All Drawings accompanying these specifications are to be read in conjunction with each other's and shall be considered as a whole. Any works indicated on them and not specifically mentioned in the specifications, and vice-versa, are deemed to be included in the overall scope of works.

Tender Drawings are design and not working drawings, they include layouts of various systems and equipment to 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, Piping, 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 Owner's/Consultant's approval.

Working or Shop Drawings

a. The Tender Drawings shall serve as working drawings for the general layout of the various items of equipment.

   However, layout of equipment, accessories and piping systems are diagrammatic unless specifically dimensioned and detailed. Dimensioned shop drawings for the installation of the work shall be prepared and submitted for approval. These shop drawings shall be new drawings prepared by the Contractor and shall not be reproductions of tracings of the Consultant's drawings. In preparing shop drawings, Contractor shall establish lines and levels for the work specified and check project drawings to avoid interference with structural features and the work of other trades.

b. Shop Drawings shall include floor, site and layouts drawn to a minimum scale of 1:50, showing all equipment and piping installed under this section. For critical areas, provide section drawings to a minimum scale of 1:25. Layout shop drawings shall be given a drawing number which shall be retained throughout all revisions.

   Before starting Works on site or ordering materials and equipment, the Contractor shall submit to the Owner's/Consultant's approval working drawings showing the following:

c.- Equipment layout showing clearances and the relation of equipment, piping and cabling to spaces assigned.

- Clearances and accesses required for operation and maintenance.
- Sizes, capacities, locations and fixing methods of equipment and items supplied.
- Equipment bases, fixings, anchoring details and supports, etc…
- Particular details pertaining to special conditions that may be required by the Owner, such as Flow Diagram showing Steam, Water, Fuel, Blowdown, Drains and Feed water lines.
- Control Cabinet Wiring Diagrams for Boiler and Pumps.

d. Working Drawings shall be submitted in Triplicates to the Owner.

e. Supplier's approved shop drawings shall be submitted for the Owner after ordering. Should it be necessary, working drawings shall be revised accordingly.

f. The Owner/Consultant reserves himself the right to approve, modify, alter or reject working drawings if found incomplete or not complying with the requirements of the Tender Documents.

Tests

Factory Tests

The packaged Boiler must be Factory Tested prior to shipment as detailed elsewhere to check the performance construction, controls and operation of the unit.

Test Certificates

Upon Owner's/Consultant’s request, the Contractor shall submit Test Certificates for equipment and items supplied.

Test Certificates shall be issued by an approved inspection authority testifying that equipment or item in question meet its testing conditions and are in conformity with the stipulations of these specifications.

Start-up , Fire tests and Reports

- After Boiler Installation, the Manufacturer shall make available the services of a Field Representative Engineer of the Manufacturer for Starting-up the Boiler.

- Upon Conclusion of the commissioning of the Boiler by the Manufacturer's Representative, an Operation and Performance test shall be scheduled to be witnessed by the Owner, the Consultants and Technical personnel.

- The normal operating test period shall be for at least one day. The Customer shall witness the boiler operation at various pressure and load conditions to ascertain the proper operation of the Equipment and Controls.

If any defects or malfunctions of the Equipment or Controls show up, the Boiler shall be stopped immediately and the Contractor shall, at his own time and expense, repair, replace or adjust again and a second test for another full day will be called for.

The Test shall be carried on until successfully completed, to the satisfaction of the Consultant.

A Report shall then be drawn and signed by the Owner and the guarantee period shall commence from the date of the Report.

The Report shall include the final settings, and readings, on full load conditions.

E. **DELIVERY**

The Test and Report, successfully completed as witnessed by the Customer and Consultant shall be considered as a Certificate of Primary Delivery.

At the conclusion of the 12 months Warranty, a final Delivery Certificate shall be issued.

TRAINING OF PERSONNEL

a. The Manufacturer Representative shall train the Owner's Operators during Commissioning and Start-up, after Delivery for a period of not less than 2 days.

   The Training shall cover standard Start-up and Operation Procedures and Regular Maintenance works.

b. The Contractor shall be responsible to instruct the personnel team that may be assigned to him by the Owner 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.

c. The Manufacturer Representative shall at the completion of the project demonstrate the operation of each system and piece of equipment to the Owner and Engineer. Demonstration shall include automatic operation of controls and safety devices to show proper setting of these items. The Manufacturer Representative shall instruct the Owner in the proper method of operation, maintenance and lubrication.

F. GENERAL BOILER DESIGN & CONSTRUCTION

The Water Boiler shall be of the fully packaged, Automatic, Horizontal tubular, fire tube, steel construction, Multi-pass, dry back, with Min. 5 square feet (0.46 square meter) of Heating Area Fireside per rated boiler horsepower.

It shall be designed as Per ASME Code for Water with a Design Pressure as shown on capacity schedules.

It shall be mounted on an integral heavy steel frame with integral forced draft burner and burner controls.

The unit shall be ready for immediate mounting on floor or simple foundation and ready for attachment of water, fuel, drains, electrical and expansion/relief lines connections, to be operational.

The boiler shell shall be welded construction and in accordance with ASME Boiler code and must receive authorized boiler inspection prior to shipment, as detailed elsewhere in the Specs.

All refractory brickwork shall be high-temperature fire-brick and/or pre-cast refractory shapes laid with high-temperature cement. It shall all be factory pre-installed.

The rear burning chamber shall be lined with high-temperature pre-cast refractory and backed with seal welded steel lining to prevent flue gas short-circuiting.

The Fire-Tubes shall be electrically welded steel construction, fitted in accordance with Boiler & Pressure Vessel Code for a Design Pressure as per capacity schedules into accurately tube sheet holes.

Tubes shall be attached to tube sheets by expanding roll-flare, fillet welding and beading operations.

The Tubes shall be properly located, staggered & aligned to permit adequate water exposure and tight rolling in place without noticeable deformation or undue stress.

All beads shall be flat tight against tube-sheet allowing no voids. A final parallel-cylindrical touch-up roll shall be applied to the tube ends after the beading operation.

The front and rear doors shall provide quick and full access to tube-sheets and tubes for inspection, cleaning and repair.

The doors shall be lined with fire resistant gasketing sealant material to ensure complete gas-tight joints.

The rear door shall be designed in one or more sections for ease of removal and to allow access to any section of the fireside surface without removing the entire door.

The lower rear section shall be refractory-lined as required by ASME Code.

The refractory-lined section shall be supported by a hinged davit arrangement for ease of removal and pivoting by one person.

All doors and sections of cover shall be bolted with heavy duty nuts and washers to studs welded to the shell.

The rear door shall include a rear Hi-temperature Pyrex peep-sight glass assembly to enable viewing the flame in the furnace tube.

The front door shall be insulated where necessary. It shall include a front peep-sight glass and cover. Further, the front door shall include a clean-out opening for cleaning without need for opening the door.

The clean-out cover shall be adequately insulated and gasketed with fire-resistant material and bolted with stainless steel bolts to front cover.

The Boiler shell shall be fitted with oval handholes as per the ASME Code requirements, to allow for inspection, cleaning and draining of the boiler shell.

The handholes shall be located at judicious locations to enable inspection of the fire-tubes at different areas along the Boiler shell.

The number of handholes shall be as required by the ASME Code.

The handholes openings shall be 3 1/2 x 4 1/2, Oval, equipped with yoke-types clamp covers.

The Boiler Shell shall be fitted with one large oval Manhole 12"x 16” as per latest requirements of the ASME Code, equipped with double Yoke and Clamp cover.

All flanged connections shall be Class 300 PSI Rating and all threaded and socket weld fittings shall be 3000 PSI rating.

Boiler Shell outlets shall include for the following connections:

- Hot Water boiler supply and return outlets
- Bottom blow-down & drain
- Safety valves
- Low water cut-off
- Pressure-Temperature gauges

- Other required outlets for Water controls & trim, such as aquastats, second blow-down connections, etc...

The Boiler shall be supported on an integral sturdy heavy gauge iron-frame skid, ready for immediate mounting on floor or simple foundation.

The skid should be high enough to allow space for clearing the bottom blow-down drain lines and Feed water connection.

The Boiler shell shall include 2 heavy lifting-lugs for transport facility

The Boiler shall be covered on sides and top with a minimum of 2" glass wool or fiberglass insulation, strapped to the Boiler shell and protected by a 22 gauge sheet steel jacket.

The entire boiler, base frame and other components shall be factory painted before shipment, using hard-finish synthetic fire-resistant enamel. All nameplates, gauges, valves shall be masked and left unpainted.

G. BOILER TRIM & CONTROLS

The following trim and controls shall be factory-mounted and piped, in accordance with the ASME Code and the Underwriters Laboratories Requirements.

The boiler shall be equipped with the following trim fittings:-

- Low-water cut-off with alarm switches, complete with Drain Valve.
- Safety Valves number and size per A.S.M.E Boiler Code.
- Pressure Gauge, with Siphon, Inspector Tee and cocks.
- Temperature Gauge
- Main Water Inlet and Outlet Valves
- Drain Valve
- Water diverting valve (Aqua-temp).

In addition, the boiler shall be equipped with :-

- A Temperature Safety/Hi-Limit switch.
- A separate Temperature operating Limit control,
- A Temperature lo-fire hold control
- A proportional/modulating Temperature control.
- A Stack Thermometer/Factory mounted at vent outlet of boiler

Low Water Cut Off'.

The Low-Water Cut-Off shall be rated at 175 PSI .

The LWCO switch shall be wired in the burner control circuit to prevent burner operation if the boiler water falls below a safe level. A Manual reset device shall be used

on this control. The Burner shall not re-start until Boiler Operator has ascertained the cause of the burner shutdown. He will then manually re-set the unit.

Further, the LWCO shall be equipped with a Manual blow-off valve to enable regular blow-down of the float chamber.

Safety Valves

Safety valves shall be of the spring-loaded self-resetting type with side outlet. The number, size and capacity of same to conform with ASME Code requirements.

These will be of the adjustable type, with hand-lever for manual Testing and factory-set and sealed at 175 PSI.

Temperature Gauge

Water Temperature gauge shall be located at the top center line of the boiler shell, near the front end.

It shall be dial type 6" size, 250 F. Range.

Pressure Gauge

A pressure gauge shall be located at the top center line of the boiler shell, close to the front end.

It will be 6" size, 300 PSI Range with zero adjustment.

It shall be equipped with a pig-tail siphon, Inspector test Tee and shut-off cock.

Boiler Inlet and Outlet Valves

Hot Water supply and return valves flanged type 175 PSI class.
Inlet shall be double regulating and outlet valve shall be OS & Y gate type.

Drain Line

The drain valve shall be supplied loose by the boiler Manufacturer for field installation. It shall be of the gate type, 175 PSI Class.

Boiler temperature Controls

The boiler water temperature controls shall be of the adjustable type with subtractive differential. They will be mounted directly on the boiler shell. The bulbs will be set in a well-type copper sheath.

The Controls shall include:

- A Hi/Safety limit - Range 250 deg.F. range

- An Operating limit -Range 250 deg.F. range

These automatic controls with adjustable main and differential ranges, will provide on-off operation and will be wired in series for added protection.

They will be of the automatic reset type, 'break' on Temperature Increase, similar to Honeywell L6006A

- An Automatic low-fire hold switch, to prevent burner going to hi-fire at cold start.

  This will be wired in conjunction with the Modulating Control and will "make" upon Temperature increase.

  It will be with adjustable main Temperature range and automatic reset, similar to Honeywell L6006B

- The Modulating control shall be of the proportional type. It will be of the adjustable setting and modulation range, similar to Honeywell T991 Series. It will be wired in the mod-motor circuit.

Stack Thermometer

A Stack Thermometer - factory mounted at the vent outlet of the boiler shall allow reading of the out-flowing flue-gases temperature.

It shall be of the bi-metal, 3" min., dial type - 1000 degree F Range, with 12' stem. It shall be used to monitor the flue gas Temperature : gradual increase of the hot gases will indicate that the boiler fireside is soothed and requires cleaning.

H. BURNER ASSEMBLY

The Burner shall be designed for firing light-oil #2, with full on-off, Hi-Lo firing, as per the Technical Schedule.

It shall be of the gun-type, forced draft, pressure mechanical atomizing type, attached directly to the furnace tube.

The Burner location will be such that combustion takes place within the water side of the Boiler.

It shall be supplied factory mounted and fully wired to the boiler controls by the Boiler Manufacturer.

The Burner shall be manufactured by the Boiler Manufacturer and the Boiler-Burner package shall be single source responsibility.

The blower shall be direct driven, by the burner motor with the blower supplying all the necessary air for the combustion.

The blower air supply shall be governed by an Air Damper at the blower inlet.

The Oil flow shall be provided by a fuel oil pump directly driven by the burner blower motor.

The Ignition shall be electric direct spark using a 10,000 V transformer.

The Burner shall include a bolted access plate removable for easy access to the nozzle/Electrode assembly. The plate shall include an observation port for viewing the flame.

I. BURNER FLAME AND PROGRAMMING RELAY

A solid state Flame Detector and Flame Safeguarding and Programming Relay, shall equip the burner. It shall be of the microprocessor type with digital display of the status, flame signals and causes of lockouts.

The purpose of the Flame Relay is to sequence and monitor the firing operation and lockout on safety for unsafe conditions.

The Relay shall be designed for Infra-Red Radiation Detection, complete with replaceable Controller, Programmer and Amplifier modules.

It shall be equipped with Infra-Red scanner cell, factory-mounted, wired and fire-tested at the factory.

The Flame Relay shall be wired and operated in conjunction with the start-up and Running interlocks.

It shall provide for the following:

- Ensure Pre-Combustion Air-purge (Pre-Purge)
- Prove burner air damper at low-fire position, at end of pre-purge before ignition.
- Control and energize the ignition controls to establish the pilot and the Low Fire.
- Scan and prove pilot and Low-fire.
- Interrupt ignition at end of trial period. Release burner to automatic control at end of start-up cycle.
- Constantly monitor the main flame throughout the running cycle.
- Provide Post - Combustion Air-Purge (post-purge) before complete shut-down of the operation cycle.
- Provide continuous self-check, on all its composite modules.

- Provide digital display of Status Signals, Faults, Alarms and causes of Safety lock-outs.

All the above as per up-to-date Code / U.L requirements.

J. BOILER CONTROL PANEL & ELECTRICALS

Boiler Panel

A fully factory pre-wired, tested and mounted Boiler Electric panel shall be installed at the front end or side of the boiler.

It shall be conveniently located for the operator. It shall be ready for field connection of the 3-phase Power mains to be operational.

The control panel shall be fully enclosed, hinged, dust-proof and NEMA 1A Enclosure. It shall be painted with the same color as the boiler casing and complete with latch and lock.

The Control Panel shall include:

- A step-down 380/120 V Control Transformer
- Control and Power Fuses
- All relays and transformers
- A 3-phase blower motor starter with overloads and auxiliary contacts
- The Flame safeguard and Programming Relay complete: Base,
- Chassis and Modules as outlined elsewhere
- Terminal strips, numbered for easy tracing of wiring, complete with all hardware,
- Extra free terminals and Earth lugs.
- Diverting 3-way valve power and control take-off.

  A secondary panel could be used to house the controls of the diverting valve. It will be wired in conjunction with the main boiler panel.

Wiring

All wires shall be neatly strapped and colour coded/numbered in agreement with the schematic of the Boiler Panel.

All wires running out of the panel shall be installed within conduits and terminated at the punched holes to the panel sides, with the required hardware as per N.E.C Code.

Exceptionally, the lead sulfide Infrared scanner cell wires shall be routed in a separate conduit.

All wiring to conform to NEC applicable Codes.

Panel Switches and Signal Lights

The panel shall include further, mounted externally:

- Signal lights with Amber, Red and White lens for visual indication of Ignition on-Main flame on-Alarm condition

- An On-Off toggle type switch

- A manual Potentiometer for manually setting the firing rate motor, with a Manual-Auto switch.

- A High-Fire Limiting Potentiometer for limiting the firing rate in periods of prolonged low load demands

- An Alarm Bell or Horn to sound out in case of Flame Failure or Low Water condition, with a silencing switch. The switch shall turn-off the bell but the alarm light shall stay on until the failure condition has been corrected.

The Panel shall include a small glass window to view the digital display of Flame Safeguard and Programming Relay, without the need for opening the panel Door.

Wiring Diagrams

A copy of the Boiler Electric schematic Diagram shall be glued to the inside door cover and covered with adhesive transparent plastic for protection.

Note: A copy of the Factory Test Report shall also be glued to the inside of the Electric Panel Board.

Additional copies of both above shall be included with the boiler literature as outlined elsewhere.

Test and Report

The normal operating Test Period shall be for at least 3 consecutive days. The Owner/Consultant shall witness the Aqua-Temp Valve and Boiler Operation at varied Heat Load conditions to ascertain the proper operation of Equipment and Control. If any defects or malfunctions of the equipment or controls appear, the Boilers shall be stopped immediately and the Contractor shall, at his own expense, repair or adjust again and a second Test for 3 other days will be called.

The Test shall be carried on until successful, to the satisfaction of the Owner/Consultant. A Report shall then be drawn by the Contractor and signed by the Owner/Consultant and the Guarantee Period shall commence from the date of the Report. The Report shall include the final Temperature Settings and Readings on full Load Condition.

Warranty

After Setting up of the Boiler Temperature Controls, the Contractor will be responsible during the Guarantee Period for the Boiler-Burner-Aqua-Temp Package as one Operational Unit.

SUB-SECTION 1506

H.V.A.C.

1.01 GENERAL REQUIREMENT

- The works covered under this Section shall include all the supply, installation, testing and delivery in good operating conditions of a complete Ventilating and Air Conditioning system as described, shown detailed or implied in the tender documents of the project.

- The Contractor shall provide all the necessary components and accessories as well as manpower, scaffolding, painting, testing facilities, etc... at his own expense to execute a complete operable system.

- The works specified in the following sections are included in this Section in each applicable part, as if repeated herein verbatim.

  - General Requirements.
  - Pipes, Valves, Pumps and Accessories.
  - Controls and Instruments.
  - Insulation and Lagging.
  - Painting.
  - Tests.

- The Contractor shall program his work such that it will not interfere with other trades and to suit site requirements.

1.02 DESCRIPTION OF THE WORKS

- The HVAC works shall consist of :

  1- Heating Raiators
  2- Ventilation Fans
  3 Split A/C Units

1.03 SEALED TYPE (CLOSED TYPE) EXPANSION TANK

Supply and install wherever shown on the Drawings one expansion tank of the sealed type of capacities as shown on the Drawings. Separate air charge from system water to maintain design expansion capacity by a flexible diaphragm securely sealed into tank.

Tank shall be constructed of welded carbon sheet steel.

Each tank shall consist of the following items, all wired, piped and packaged into an automatic unit.

- Pressurizing pump, centrifugal end suction type.

- Expansion tank, constructed of welded black steel 3mm. thick, and complying with ASME recommendation.

- Suction water tank with ball valve, pressure switch for pump control.

- Non-return valve, pressure regulating valve and gauge.

- Hand-off-Auto starter.

- High and low pressure cut out switches, which operate the pump when the pressure drops due to loss of water from the system.

- Necessary expansion vessels and valves.

Approved Manufacturers:

- PACO
- Bell and Gossett Co.
- AURORA

or approved equal.

Tank shall be tested for leaks before installation.

1.04 **Mini Split A/C Units**

General

Mini split system shall cover a range up to three tons of refrigeration and shall consist of a condensing unit, an evaporator blower unit, cooling/heating operation for all seasons, and refrigerant piping network between the blower coil and the condensing unit.

Condensing Unit

Condensing unit shall be of the air cooled type completely assembled at the factory and shall consist of the following:

- Phosphatized zinc coated steel casing.
- Hermetic Compressor.
- Air cooled condenser and condenser fan.
- All necessary controls and accessories for automatic and proper operation.

Evaporator blower Unit

The evaporator blower unit shall be installed indoors and shall be of the type indicated on the Drawings.

The unit shall be complete with:

- Heating/cooling unit.
- Centrifugal 3-speed blower and blower motor.
- Cleanable filter.
- Thermostat and speed selector switch.
- Decorative cabinet if installed exposed.

H) **Approved Manufacturers**

- Carrier Corp.
- Trane Co.
- O-General
- Daikin

or approved equal.

1.05 **RADIATORS**

- The contractor shall supply and install radiators of the type and capacities as indicated on the drawings.

- Each radiator shall be of the sectional type.

- Each radiator shall be complete with the following:

  - Supply valve
  - Manual air vent
  - Manual flow adjusting bronze elbow
  - Wall brackets.

- Each radiator shall have two coats of finishing paint over the base paint.

1.06 VENTILATING FANS

A) General

- The Contractor shall supply and install where shown on the Drawings, fans as described hereinafter and of capacities indicated in the Capacity Schedule on the Drawings.
- The ventilation system shall be in strict accordance with the requirements of ASHRAE Standard 62.1-2007
- The fan motors and starters shall be in accordance with the Electrical division of these specifications.
- Test and rate all fans in accordance with the standards of the AMCA. All fans must bear the AMCA certified rating seal.
- Make appropriate allowance for the effects on fan performance of all installation conditions including plenum enclosures and inlet and discharge arrangements so that actual installed fan performance equals that specified.
- Balance all fan wheels and all other moving components statically and dynamically. Where coating is specified and it affects the balance of the fan wheel, perform balancing after the coating has been applied.
- Drill all fan shafts on the centerline to receive a tachometer.
- Belt driven fans shall be connected to the driving motor by means of an approved V-belt drive, with adjustable sheaves, unless otherwise designated. V-belt drives shall be designed for 50% overload capacity and the motors for such drives shall be equipped with adjustable bases or slide rails.
- Bearings shall be self-aligning, grease lubricated, ball bearing type, and shall be complete with grease fittings, extended for easy access where necessary.
- Weatherproof hoods should be provided for all motors and drives exposed to weather to the approval of the Engineer.
- Back draft dampers, gravity type, shall be installed on the fan discharge of all fans discharging directly to the atmosphere except the kitchen hood fan.
- Fans are to operate steadily without pulsation at design conditions. Centrifugal fan characteristic curves must be such that the fan operating point falls below the point of no flow static pressure, to the right of the point corresponding to that of maximum mechanical efficiency, and a 15% increase in static pressure over that specified results in not more than a 15% reduction in cfm and does not affect the stability of fan operation. If necessary accomplish the foregoing by modifying the width of the wheel and/or by providing inlet vanes to change the characteristic curve.
- Performance curves shall be submitted for each fan for approval.

B) **Roof Ventilators**

Each roof ventilator shall be of the centrifugal vertical discharge type coupled through a belt drive to its electric drive motor suitable for roof mounting and outdoor operation.

Each roof ventilator shall be complete with:

- Electric motors suitable for outdoor operation.
- Aluminum protective cowl and body.
- Metallic fixing and supporting frame.
- Weather proof non fused disconnect switch under fan cowl.
- Galvanized steel bird screen.

C) **Centrifugal Fan**

Fan shall be of the centrifugal double inlet width, or single inlet width, as shown on plans, backward curved blades type with non-overloading design wheel diameters and outlets areas shall be in accordance with the standard sizes adopted by the AMCA for non-overloading fans. Inlets shall be fully stream lined and housing shall be suitably braced to prevent vibration or pulsation.

Fan shall be supplied complete with:

- Electric motor mounted on one chassis with the fan.
- Reinforced heavy gauge fan casing.
- Metallic fixing frame and supports.
- Pulleys, belt drive and belt guard (of expanded metal with tachometer hole).
- Vibration isolators.

- Fan wheels with die formed backward curved blades designed for maximum efficiency and quiet operations. Wheels shall be statically and dynamically balanced.

- Heavy flanges on both sides of housing. Flanged joints shall be gasketed for air tightness.

- Fan inertia should be checked against motor capability. If fan inertia is found larger, then a centrifugal or plate clutching service should be used to enable the fan to be brought up to speed without damaging the motor.

- Motorized damper at fan outlet to open and close with fan on/off operation.

- Parking exhaust fans shall have the fire/smoke rating shown on the drawings.

E) **Centrifugal In-line Fan**

Fan shall be of the centrifugal in-line type all aluminium construction and shall be complete with:

- Electric motor mounted outside the air stream, when air temperature inside the duct is above 200 ^{O}F (93 ^{O}C), otherwise inside air stream.
- Metallic fixing frame and supports.
- Dust proof, non fused disconnect switch under motor casing.
- Belt drive and belt guard or as stated in Capacity Schedule.
- Vibration isolators.
- Aluminium air foil blades impeller with non overloading horse power characteristic.
- Flexible duct connection at each end.

F) **Approved Manufacturers**

- Barry Blower Co.
- Greenheck
- Woods. - Loren Cook Co.
- Power Line

or approved equal

1.07 **PIPING AND VALVES**

Piping shall be supplied and installed as specified under "Pipes, Valves, Pumps and Accessories" section.

1.08 **DUCTWORK**

A) **General Requirements**

- Supply and install, where shown on the Drawings, galvanized sheet steel ductwork, complete with all necessary bracing and supports. The Contractor may propose Pre-insulated Duct System as an alternative to the galvanized sheet steel ductwork, provided that it is provided at no extra cost the Employer. If the Contractor intends to propose the Pre-insulated Duct System during Construction, he shall submit so complete with all Technical Data for the review and approval of the Engineer.

- All rectangular ducts shall be of the low pressure rating, except where indicated on the Drawings.

- Galvanized sheet steel shall be fabricated, erected and installed in accordance with “SMACNA" sheet metal manuals.

- Galvanized sheet steel ducts shall be of G90 coating designation within ASTM A525-75, standard specification for ‘steel sheet zinc coated by the hot dip process'. The weight of coating on both sides of duct shall be 0.9 oz/ft2 (275g/m2) as a minimum check limit triple spot test.

- The ducts gauges, thickness, type and method of jointing shall be as detailed and tabulated on the drawings and/or in compliance with ASHRAE Standards and Handbooks.

- All ducts shall be constructed and erected so as to be rigid and free from sway, drumming and movement. Ductwork shall be true to sizes indicated on drawings, straight and smooth on the inside with neatly finished joints. Whenever internal acoustic lining is indicated on the Drawings, the duct sizes have to be increased to accommodate the lining.

- Ductwork joints shall be square with all sharp edges removed.

- The ducts shall be routed with a minimum of directional changes and abrupt transitions.

- Adequate space shall be provided around ducts to assure proper support and to allow the installation of the specified insulation.

- All connections between ductwork, including flexible connections, fittings and equipment, shall be made with gradually tapered transition fittings.

- Whenever a flexible duct is used to correct misalignment between the supply duct and the diffuser ceiling location, the misalignment (or offset) shall not exceed one-eighth (1/8) the length of the collar (or diffuser diameter).

- Changes in section of ductwork shall be effected by tempering in ducts with as long a taper as possible. All branches shall be taken off at not more than 45 degree angle from the axis of the main duct unless otherwise approved by the Engineer.

- The ducts shall be securely anchored to the building in an approved manner.

- The ducts shall be installed as to be completely free from vibration under all conditions of operation.

- The ducts and hangers shall be installed straight, plumb and level.

- Wherever ducts pass thru walls or floors, a sleeve of galvanized mild steel sheet shall be provided and the space between the insulated duct and the sleeve shall be caulked with lead wool and finished on each face with a mastic fill.

- Flexible ducts should be kept as short as possible and fully extended.

- All slip joints shall be made in the direction of flow.

- All elbows shall have a centerline radius equal to at least 1.5 times the width of the duct, otherwise turning vanes shall be installed in the elbows.

- Adjustable splitters and hinged volume dampers shall be provided at every duct junction on both supply and exhaust ductwork for adjusting air volumes.

- Where splitters and dampers are installed above suspended ceiling, flush-mounted controlling devices shall be used.

- Connection to diffusers, grilles and registers shall be made absolutely airtight.

- Equalizing grids or turning vanes shall be installed ahead of an air outlet whenever poor approach conditions, from the main duct to the outlet, exist.

In critical low noise level projects, poor approach conditions are not allowed.

- Where the duct is pierced for any reason, sealing compound shall be used.

- All joints and fittings concealed in vertical duct shafts shall be welded.

- All rectangular metal ducts shall be sealed in accordance with ASHRAE Standard 90 and SMACNA low pressure duct construction standards. All high pressure ducts shall be air tight.

D) **Protection and Cleaning**

- During construction, cover all open ends of ductwork with one layer of canvas.

- Remove all foreign materials and clean the duct inside and outside.

- Clean ducts before operating fans and filters. Never operate fans unless filters are installed.

- Operate the fans and thoroughly blow out the interior surfaces of the ductwork.

- After tests, wash cleanable filters and replace renewable media.

E) **Hangers for Ducts**

- Supply and install steel work necessary for the support of the ductwork. Hangers shall be spaced not more than 3000 mm. apart, and at changes of direction. Types and construction of hangers shall be as detailed on the Drawings and in compliance with SMACNA recommendations.

F) **Volume Dampers**

- Supply and install volume dampers with locking levers and quadrants, indicating their position in main ducts and in all branch ducts supplying three (3) or more air outlets, in all fresh air intakes and where shown on the Drawings.

- Volume dampers shall be of the butterfly type for ducts 15" (380 mm) in depth and lower, and multiple opposed blade type for ducts above 15" (380 mm) in depth. Maximum blade size shall be 48" x 10" (1220 x 250 mm).

- For ducts larger than 48"(1220 mm), multiple frame sections shall be used. Blades shall not be less than 18 gauge. Duct shall be stiffened at damper location. Volume dampers for circular ducts shall be of the multiple opposed blade type fitted in a square section.

- Upon completion of the ductwork, dampers shall be adjusted and set to deliver the amounts of air indicated on the Drawings.

G) **Curtain Type Fire Dampers**

Supply and install fire dampers on location shown on the drawing. Each fire damper shall have a 1 ½ hour fire protection rating and a 165 °F fusible link.

Fire damper frame shall be constructed of 20 gauge galvanized steel channel. Blades shall be curtain type of 24 gauge galvanized steel and finish shall be mill galvanized to ASTM A525 g-60.

Each fire damper shall be constructed and tested in accordance with UL Safety Standard 555.

- Fire dampers shall be equipped for vertical for horizontal installation. Horizontal mounted dampers shall be spring loaded.

All necessary accessories such as sleeves, angles, etc., shall be provided for proper installation of fire damper as per manufacturer's instructions

H) **Flexible Connections**

- Flexible connections of approved flame retardant fabric to prevent the transmission of vibration through the ducts, shall be installed on both the supply and return sides of all fans and ventilating units for a maximum length of 250mm. and a minimum of 100mm. in the direction of the flow.

- Flexible connections shall connect ducts across structural expansion joints.

- Cloth used for flexible connections shall be of proper weight and strength for the service required, and shall be properly fitted to render it relatively tight.

- Neoprene laminated fabric, with neoprene facing on interior surface shall be used for ducts handling other than clean dry air.

J) **Belt Guards**

- Guards shall be provided for all belt-driven units.

- Guards shall be made to enclose both pulleys and belts on exposed sides and shall be constructed of galvanized steel top and bottom with perforated or expanded metal front Pittsburgh-locked into the rim.

- The entire assembly shall be rigidly supported.

- Provision shall be made for accessibility of all points drilled to receive tachometer.

- Provide coupling guards on direct-connected units.

- Guards shall be designed for easy removal for service and shall comply with Underwriters' Safety Requirements.

K) **Noise Attenuation**

The Contractor shall supply and fix acoustic insulation and noise attenuator units where necessary to reduce the air borne noise transmission through the distribution duct system, so that the specified noise criteria levels are satisfied.

- Attenuator Units

The attenuator units shall be inserted in the ducts where they pass through the mechanical room walls, the gap between the wall and attenuator being packed with felt to form an air tight seal. However where this is not possible, the attenuator shall be fitted in the duct between the fan and the mechanical room wall with the duct between the silencer and the wall acoustically lagged to prevent noise re-entry. Attenuators shall consist of attenuator splitters which are assembled in one attenuator casing. Splitter case shall be made from galvanized sheet steel: absorption material moisture repellent and abrasion proof up to approx. 3600 fpm. (18 m/s) air velocity, control plates on surface of splitters is made from galvanized steel sheet.

Sound attenuator casing shall be made from galvanized sheet steel, with pre-drilled angle flanges.

Attenuators or splitters of large cross section or length can be manufactured in modular section as required for ease of site handling.

- Furnish and install duct lining wherever shown on Drawings.

- Where it is possible to achieve the required attenuation by lining the interior of duct runs, this may be accomplished by applying one inch thick lining to the inside of the ducts, and shall be 24 kg/m3 density with woven glass fiber facing, similar to kimmco (K.C.L) or any approved equal..

- Lining for rectangular ducts shall be semi-rigid fibrous glass blanket and for round ducts shall be flexible fibrous glass blanket, both with special surface treatment and for apparatus casings, large plenums, and masonry air shafts shall be rigid coated fibrous glass board.

- Acoustic insulation shall be suited to the atmosphere in which it is to operate, and shall be incombustible or self- extinguishing non-flame spread grade, vermin proof and adequately fixed to ducting or mechanical room walls. Liner density shall be 3 lbs. per cu. Ft.

- Duct liners shall be applied with both mechanical fasteners and an adhesive. Adhesives must be both water and fire resistant.

  Mechanical fasteners could be either of the welded pin or impact pin types. The length of each pin shall be enough to accommodate the specified liner thickness. Washers on top of the pins shall retain the liner.

L) **Access Openings**

- General

  Access doors shall be provided for volume damper quadrants installed in concealed spaces, for control valves, for fire dampers, or as specified hereinafter.

  All access openings shall be rigidly framed and made airtight. Covers shall be simply and speedily removed and re-fixed. Multiple set screws or self-tapping screws will not be acceptable as a method of fixing. Access doors and other openings in ductwork shall be provided for the purposes given below. The number, size and locations shall be as indicated on the drawings or as necessary to ensure adequate access to equipment and plant.

- Access for Personnel

  Access doors shall not be larger than 1350mm. high by 500mm. wide, unless essential for equipment handling. Doors shall open against the air pressure. Duct openings and the access doors shall be adequately reinforced to prevent distortion. Suitable sealing gaskets shall be provided together with sufficient clamping type latches to ensure airtight and watertight sealing between the door and the duct. All personnel access openings shall have latch handles on both the inside and outside of the door.

- Access for Maintenance, Cleaning and Inspection

Inspection openings shall generally not be larger than 300mm high by 400mm. wide unless essential for access to equipment, in which case the size shall be agreed before manufacture. The opening in the duct shall be adequately stiffened and the door cover sufficiently rigid to prevent distortion. Approved sealing gaskets and suitable fastenings shall be provided to ensure airtight sealing.

- Test Holes for Test Equipment and Instruments

  Test holes shall be provided wherever instructed by the engineer, and in all main ducts and branch ducts to correctly establish design air flows and to check the performance of fans and regulating dampers. All holes shall be 25mm. dia. and suitably strengthened. Cover plates shall be screw-fixed to the duct and sealed.

- Access Openings in Insulated Ducts

  Where ducts require to be thermally insulated the door frame shall be extended beyond the face of the duct by a measurement equal to the thickness of the insulation and as arranged so that the insulation can be 'dressed' into the frame. Doors or covers shall be suitably insulated and provisions made to ensure that the seal is continuous across the whole opening. The extent of the opening shall be clearly visible or otherwise indicated. Where it is impossible to vapor seal an access opening, provision shall be made for collecting and draining condensation.

1.09 AIR DISTRIBUTION OUTLETS

A) General Requirements

- All air outlets shall be of, at least the sizes indicated on the drawings, with the noise spectrum of the supply outlets no higher than NC- 35. Outlets shall be supplied with foam rubber gaskets to prevent air leakage.

- Where supply or return outlets are installed in continuous line, omit intermediate frames and margins. Provide guides for each element to keep adjoining lengths aligned and butted without breaks. All outlets shall be constructed of anodized aluminium of the color specified here in after or as selected by the Engineer. Outlets causing excessive air movement, drafts or objectionable noise shall be replaced at no cost to the owner.

- All outlets shall be erected square and level and accurately set in position, to ensure symmetry with other grilles, light fittings, etc. It has been arranged that final minor adjustments to suspension levels to obtain final accurate alignment between the ceiling and light fittings, diffusers, etc., shall be executed by those responsible for erecting the false ceilings.

- Any imperfect outlet scratched or damaged surfaces of fixing screws having damaged heads, or scratched plating, will be rejected and shall be replaced satisfactorily before the Contract Works will be taken over as complete.

- Samples showing finish and color shall be submitted to the Engineer for approval prior to supplying the outlets to Site. The Contractor shall provide in his Tender for delaying the fixing of loose grilles until all other trades have completed their work, returning to the Site to fit the grilles as and when required to do so.

B) **Air Diffusers - Square**

- Supply and install diffusers where shown on the Drawings.

- Air diffusers shall be of the diffusion and air mixing type and shall be made of white anodized aluminium.

- Supply air shall be diffused with no air velocities in excess of 50 fpm. (0.25 m/s) 1800 mm or less above the floor line. Room air shall be mixed with the primary air by induction to effect subsequent uniformity of the room temperature without stratification.

- Each diffuser shall be provided with an aluminum opposed blade damper, except for return ceiling diffusers where damper is not required. Diffuser shall not project appreciably below ceiling or duct. The inner assembly of the diffusers shall be attached to the outer assembly by means of a lock permitting assembly and disassembly without the use of tools. The noise level shall be measured at a point one meter below the diffuser.

C) **Grilles and Registers**

- All grilles shall be mounted upon substantial frames connected to the duct work, and shall be provided with soft plastic mounting rings inserted under the frame, so as to obviate leaks behind the grille.

- All supply grilles and high level return grilles shall be double deflection, with horizontal face blade in the front, with airfoil blade construction, with minimum of 19 mm flange with gasket.

- Supply registers shall be double deflection, horizontal face bars, airfoil blade construction, with aluminum-opposed blade, key operated volume dampers, and 19 mm minimum gasketed flange.

- Return grilles at low levels or transfer grilles and fresh air grilles shall be single deflection fixed blade type with 19mm. flange with gasket where the sheet metal is visible behind the grille, paint the interior surface of the sheet metal flat black.

-

D) **Fresh Air and Discharge Louvers**

- The Contractor shall supply and install where shown on the Drawings, and wherever necessary, louvers for fresh air intake, and for exhaust. They shall be white anodized aluminium.

- Louvers shall be weatherproof, with fixed blades set at 30 degree and shall have a free area of 85%.

- Louvers shall be furnished with 1/2" (13mm) mesh-bird screen secured in removable extruded Aluminium frames.

E) **Door Louvers**

- Supply and deliver door louvers to the door manufacturer for installation.

- The louver shall be extruded aluminium completely lightproof V-Section with double frame.

F) **Gravity Dampers**

Supply and install gravity dampers wherever shown on the Drawings and with the airflow direction indicated therein.

Gravity dampers shall consist of:

- Galvanized sheet steel frame.
- Aluminum blades.
- Stainless steel bearing shafts and brass bearings.
- Neoprene seal to withstand 120 deg.C. air temperature.
- Aluminum blade travel stop.

All blades shall be coupled together by means of an aluminum bar.

G) **Approved Manufacturers**

- Krueger Mfg. Co.
- Tuttle & Bailey Inc. - Environmental Elements Corp. (Titus).
- Euro. Register.
- KBE Establishment

or approved equal.

SUB-SECTION 1507

PIPES, VALVES, PUMPS & ACCESSORIES

1.01 GENERAL DESCRIPTION

This section describes materials and equipment for Plumbing and Mechanical Engineering installations as noted in the previous section of this volume of the Specification.

1.02 MATERIALS AND EQUIPMENT

Pipe and Fittings
Valves
Pumping Equipment
Vibration Isolation and Equipment Bases

1.03 WORKMANSHIP

- All workmanship required to accomplish the work mentioned hereinafter or shown on related Drawings, shall conform to the highest standards, and as required by the Engineer.

- The Engineer will be the sole judge of the standards required.

1.04 PIPES AND FITTINGS

A) Description of Work

The work included under this part shall consist of pipes, fittings and equipment, as hereinafter specified and as shown on the Drawings. Such work shall include, without being limited to the items described in the following clauses of this part.

B) Arrangement and Alignment

- Install piping in a neat, workmanlike manner and the various lines shall be parallel to building walls wherever possible.

- Install pipe groups for plumbing parallel with pipes of other trades.

- Space pipe supports, arrange reducers and Pitch piping to allow air to be vented to system high points and to allow the system to be drained at the low points. However, where obstructions exist, automatic air vents shall be installed at all air pocket points and 1/2" (15 mm) drain gate valves shall be supplied and installed at all low points and riser legs.

C) **Special Requirements for PVC Pipes**

- Storage

  PVC pipe and fittings shall be stored under cover at all times.

  Sun light shall not be permitted to come into contact with the PVC materials at any time, except during installation in trench. The pipes shall be stored on flat level ground free from large or sharp edged stones or objects, and shall be stacked to a maximum height of 1.5m. (or as recommended by the manufacturer with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

- Pipe Installation

  Before installation, the pipe shall be inspected for defects.

  Defective, damaged or unsound pipe will be rejected. Deflections from a straight line or grade, between the center lines extended, of any 2 connecting pipes made necessary by vertical curves or horizontal curves or offsets, shall not exceed 12500/D mm. per linear meter of pipe, where D represents the nominal internal diameter of the pipe expressed in millimeters. If the alignment requires deflections in excess of these limitations, special bends or a sufficient number of shorter lengths of pipe shall be furnished to provide angular deflections within the limit set forth. Except where necessary in making connections with other lines, pipe shall be laid with the bells facing in the direction of laying.

  Pipes in trenches-Place each length of pipe with a uniformly distributed bearing for the bottom 0.3 of the pipe on the sand fill in the trench. Excavate recesses to accommodate pipe bells, sleeves, glands or other fittings. Take up and re-lay any pipe that has the grade or joint disturbed after laying. Clean the interior of the pipe of all foreign material before lowering into the trench, and keep clean during laying operations by means of plugs or other acceptable methods.

  Plumbing vents exposed to sunlight shall be protected by water- base synthetic latex paints.

- Thermal Expansions

  When drainage and vent stacks exceed six (6) meters in height, approved expansion joints, restraint fittings and offsets shall be placed on vertical risers and horizontal branches as follows:

  - Expansion joints are recommended at alternate floors in all vertical stacks.

- Expansion joints shall be placed in horizontal branches containing two or more vertical risers and exceeding ten (10) meters in length immediately upstream of vertical riser whenever possible.

- An expansion joint shall be placed below the connection point of a waste pipe to the stack, if this connection is exposed below floor slab, and above the connection point if this connection is above floor slab.

- No expansion joints shall be required in building drain below grade.

- Thermal Expansion Fittings

  Approved expansion fittings that utilize rubber-o-rings in a recessed groove may be used to compensate for thermal expansion. The ring slides along the pipe when expansion or contraction occurs. Expansion joints shall be installed by solvent cementing techniques.

D) **General Requirements**

- Make all changes in size and direction of piping with standard fittings.

- Make all branch connections with tees.

- Use eccentric reducing fittings or eccentric reducing couplings where required by the contract documents or where required to prevent pocketing of liquid or non-condensibles.

- Pipe bending shall not be resorted to except in extreme cases and only after the written approval of the Engineer.

- Piping shall be designed with Loops to take the thermal expansion. Wherever this is not possible for physical reasons, expansion joints with guides shall be used.

- Installation of pipes shall be complete with all cutting, patching and making good of walls, slabs, partitions, etc., due to fixing, supporting and anchoring of pipes.

- Automatic air vents shall be installed at all air pocket locations, and/or at the highest points in the lines.

- Pipes and fittings shall both be manufactured according to one single standard unit of measurement, either both English or both metric.

E) **Connection to Equipment and Control Valves**

- Provide flanges or unions at all final connections to equipment and control valves to facilitate dismantling. Arrange connections so that the equipment being served may be removed without disturbing the piping.

- Install all supply piping, pumps and other equipment including gate valves and strainers therein, at line size with the reduction in size being made only at the outlet piping from the control valve at the full size of the tapping in the equipment served.

F) **Unions and Flanges**

Unions and flanges shall be installed at all equipment inlets and outlets, at all valves inlets or outlets, on all pipe branches and in general, every 15 meters of pipe run.

Unions shall be used on all screwed pipes and shall be of the same quality and service. Flanges, suitable for welding, shall be used on all welded pipes, and shall be all steel construction to ASTM or BS Standards.

Threaded flanges shall be used on all threaded pipes; when flanged valves and equipment are connected to the pipes, flanges shall be of the same quality and service as the pipe served, and shall conform to ASTM or BS Standards.

G) **Hangers, Supports, Anchors and Guides - General**

- Support, anchor and guide all piping to preclude failure or deformation. Construct and install hangers, supports, anchors, guides and accessories to the approval of the Engineer. Do not use wire, tape or metal bands. Supports shall be designed to support weight of pipe, weight of fluid and weight of pipe insulation.

- Fasten piping securely to the structure without overstressing any portion of the supports or the structure itself. Secure pipe supports, anchors and guides to concrete by means of inserts or if greater load carrying capacity is required by means of steel fishplates embedded in the concrete.

- Arrange hanger to prevent transmission of vibration from piping to building and supports.

- Uninsulated copper or brass pipe and/or tubing shall be isolated from ferrous hangers or supports

- Support piping and tubing at intervals indicated in the schedule hereinafter and at all changes in direction. Maximum deflection shall not exceed 3 mm.

- Clearance for application of specified Vapor sealed insulation without cutting pipeline covering or fitting covering in installation of pipe hangers and fittings shall be provided.

- Furnish pipe hangers and supports complete with rods, bolts, lock nuts, swivels, couplings, brackets and all other components and accessories, to allow installation to freely expand and contract.

- Hangers shall be formed steel clevis type, unless otherwise specified, with adjustable attachment to hanger rod. For copper or brass pipe, use plastic sheathed hangers. Pipe hangers shall fit over vapor sealed insulated piping.

- Where pipe exceeds maximum loading recommended for clevis type hanger, provide steel pipe clamps.

- Provide trapeze hangers where several pipes can be installed parallel and at the same level. Trapeze shall be of steel channel sized to support load and drilled for rod hanger at each end. Provision should be made to keep the lines in their relative position to each other by the use of either clamps or clips.

- Use roller supports, where provision for expansion is required. Rollers shall have cast iron adjustable bases.

- For hanger rods on piping 3/8" (10 mm) thru 2" (50 mm) inclusive use 3/8" (10 mm) rods, and for piping 2 1/2" (65 mm) thru 5" (125 mm) use 5/8" (16 mm) rods, and for piping 6"(150 mm) thru 12" (300 mm) use 7/8" (22 mm) rods.

- Provide additional steel members required for hanging piping systems in areas with special conditions, or where vertical or horizontal structural steel supports are required other than those provided in the structure.

- C-type hangers on sprinkler piping shall have lock nuts.

- Provide lateral bracing for supporting rods over 450mm. long braced at every fourth hanger with diagonal bracing attached to slab or beam.

- Floor supports - provide for supporting horizontal piping from floors with cast-iron rests, with pipe nipples to suit. Fasten to floor. Where provision for expansion is required, provide pipe roll stands, without vertical adjustment. Provide concrete or steel pipe piers, fasten stands to piers.

- Wall supports - provide for supporting horizontal piping from wall with steel J-Hook for pipe located close to wall and not larger than 3" (80 mm) pipe. For greater loads, up to 1500 lbs (680 Kg) maximum loading provide welded steel bracket.

- Vertical piping supports - support cast-iron soil pipe at every floor and at base of stack, other pipes at every floor unless shown otherwise. Use steel extension pipe clamps. Refer to manufacturer's rated maximum loading for each size pipe. Bolt clamps securely to pipe, rest clamp-end extension on building structure. Place pipe clamps at ceiling below, support clamp and extension from inserts where pipe sleeves extend above floor.

- Pipe-covering (insulation) protection saddles.

- Provide hanger shields to protect vapor sealed pipe insulation within mechanical equipment rooms at each support point by a 360^{o} insert of high density, 100 psi, waterproofed calcium silicate encased in a 120^{o} sheet metal shield. Insert thickness shall be same as insulation. Shield length shall equal nominal pipe diameter, minimum but shall not be shorter than 100mm. and need not be longer than 300mm. if bearing load causes no discernible deformation. Insert shall extend 25mm. beyond sheet metal shield. 100mm. shields shall be 26 gauge minimum. Shields 130 to 230mm. long shall be 20 gauge minimum. Shields longer than 230mm. shall be 16 gauge.

- Provide penetration shields to encase insulated pipes penetrating fire walls or floors in a 360^{o}, 24 gauge minimum sheet metal hanger shield with insert of high density, 100 psi. waterproof material insulation and further enclosed within the sleeve, sized for maximum 25mm. spacing between sleeve and insulation shield, pack annular space between sleeve and shield on both ends with double neoprene coated rope. Install an escutcheon plate to completely cover the wall penetration opening and fit snugly over the pipe insulation shield. Insert shall extend at least 25mm. beyond penetrated surface and escutcheon. Sleeves shall be fire Resistant at Penetration of floors and fire walls

- Provide oversize hangers with blocking the same thickness as the insulation to pitch vapor sealed insulated pipes accurately at time of insulation.

- Except for fire protection systems, maximum horizontal spacing for pipe hangers are as follows:

  - 3/4" and 1" (20 and 25 mm) steel pipe 2.5 meter
  - 1 1/4"-2" (32 and 50 mm) steel pipe 3.0 meter
  - 2 1/2"-4" (65 and 100 mm) steel pipe 4.0 meter
  - 5"-6" (125 and 150 mm) steel pipe 5.0 meter
  - 8" (200 mm) and above steel pipe 6.0 meter
  - Up to 1 1/4" (32 mm) copper pipe 2.0 meter
  - 1 1/2" (40 mm) and over copper pipe 3.0 meter
  - 2 1/2" (65 mm) and smaller PVC pipe 1.2 meter
  - 3" (80 mm) and over PVC pipe 1.8 meter

  The spacing of other pipe materials shall be in accordance with the manufacturer recommendations.

Vertical spacing - PVC pipe twice as those of hor. spacing. - other pipes - at every floor level.

- Hangers on PVC pipes shall be of design, which does not clamp the pipe tightly but permits axial movement.

- Support but do not rigidly restrain PVC pipes at end of branches and at change of direction or elevation. Vertical piping shall be maintained in the straight alignment. Support trap arms in excess of 900mm in length as close as possible to the trap.

- Approved Manufacturers

  - Fee & Mason Mfg. Co. Inc.
  - Grinnel ITT Corp.

  or approved equal.

H) **Pipe Sleeves**

- Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 2" larger than the outside diameter of the pipe for uninsulated lines or of the insulation for insulated pipes.

- Install sleeves through interior walls and partitions flush with finished surfaces; sleeves through outside walls to project 15mm. on each side of the finished wall; and floor sleeves to project 25mm. above finished floors.

- Set sleeves in place before pouring concrete or securely fasten and grout in with cement.

- Sleeve construction:

  - Interior Partitions - galvanized sheet iron.
  - Interior & Exterior Masonry Walls and Floors-galvanized steel pipe.

- Fill the space between outside of pipe or insulation and the inside of the sleeve or framed opening with fibrous fire resistant material in interior walls and floors and pack with oakum, seal with lead and watertight mastic or asphalt in exterior walls.

I) **Cleaning of Piping Systems**

- Plug all opening ends of piping, valves and equipment except when actual work is being performed to minimize accumulation of dirt and debris.

- After installation is complete, place temporary screens at connections to all equipment and at automatic control valves where permanent strainers are not provided.

- Prior to the performance of tests, flush out all piping that is to receive a hydrostatic test with clean water.

- Remove dirt and debris collected at screens, strainers and other points from the system.

- The Contractor shall disinfect water piping before it is placed in service. The Contractor shall furnish all equipment and materials necessary to do the work of disinfecting and shall perform the work in accordance with the procedure outlined

in AWWA Standard for Disinfecting Water Mains Designation C 601-68. The dosage shall be such as to produce a chlorine residual for not less than 10 ppm after a contact period of not less than 24 hours. After treatment, the piping shall be flushed with clean water until the residual chlorine content does not exceed 0.2 ppm. During the disinfecting period, care shall be exercised to prevent contamination of water in steel main.

J) **Material Tests and Identification**

- In addition to the tests required for specific piping systems, the manufacturer shall test all materials as specified prior to delivery.

- Check all materials for defects. Identify all materials with factory applied permanent stampings or markings designating their conformance to specified requirements.

K) **Hydrostatic Pressure Tests**

Test all piping systems as per the specifications under section of "TESTS"

1.06 **PIPE CLASSES**

A) **General**

The classes of all the piping materials used are listed herein below with the pressure ratings indicated.

B) **PVC Pipes – Type 1**

PVC pipes-Type 1 (Unplasticized Polyvinyl Chloride) pipes shall comply with SAS 14, DIN 80062, ISO 161/1 Class 4 UPVC pipes.

PVC pipes shall be supplied with integral grooved socket at one end suitable for rubber ring joints incorporating elastomeric sealing ring. Fittings shall be of the rubber ring joint type compatible with the supplied pipes.

PVC pipes-Type 1 are allowed to be used for drainage, sewer and storm water application and/or as specifically mentioned in the schedule of pipe materials.

C) **PVC Pipes – Type 2**

PVC pipes-Type 2 (Unplasticized Polyvinyl Chloride) pipes shall comply with SAS 14, DIN 8062, ISO 161/1 Class 5 UPVC pipes.

PVC pipes shall be supplied with integral plain socket at one end suitable for solvent weld joints. Fittings shall be of the solvent weld joint type compatible with the supplied pipes.

The pipe shall be homogenous throughout and free from visible cracks, holes, foreign inclusions or other defects. The pipe shall be as uniform as commercially practicable in color, opacity, density and other physical properties.

All fittings and accessories shall be of same material and quality as the pipe and jointing shall be of the spigot and socket cemented type where solvent cement is applied to both parts. After pushing the pipe into the socket, the joint shall be allowed to set for at least 10 hr.

Expansion joints with guides as recommended by manufacturer shall be installed on long run, every 30 meters of length, and wherever shown in the specification.

Bending PVC pipes is only allowed in non-critical application at room temperature and after the approval of the Engineer.

Before bending the pipe should be heated at the section to be bent to a temperature of about 275-300 ^{o}F (135-150 $^{^{o}}$C).

The bore should be supported by packing with sand or by insertion of thick rubber pipe, the heating being carried out in a hot air oven or by immersion in hot oil or glycerine. Overheating should be avoided, and the pipe should be held at the bending temperature too long.

PVC pipes-Type 2 are allowed to be used for water supply piping application, and/or as specifically mentioned in the schedule of pipe materials.

D. **Polypropylene Pipe**

Polypropylene (PP-r) piping system (pipe and fittings) shall be used hot and cold-water installations .

Approved Manufacturer: The pipe and fitting manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials. The manufacturer shall have a document control procedure, which allows for traceability of manufactured products… It is mandatory for the manufacturer to be operating and producing under ISO9001:2000 quality requirements.

1. Polypropylene Pipe

PP-r pipe shall be manufactured from approved Raw materials in accordance with DIN 8078 and/or prEN 12202-Part 1 and Part 2.

Produced pipes must be rated PN20 Wall thickness. Mechanical Characteristics, Mean outside diameter and out of roundness together with their tolerances must comply with DIN 8077 and /or prEN 12202-Part 2.

Pipe Packaging – All pipe sizes will be supplied in straight lengths of 4 m each. Packaging of pipes will differ according to size.

Marking of Pipe - All pipes shall bear permanent identification markings that will remain legible during the service life of the product. Marking on pipe shall include the following and shall be applied at intervals of not more than 1.5 meters:

- Trademark and Nominal diameter and thickness
- Standard PPr designation (i.e. PPr80 or PPr-type3)
- The Standard Dimension Ratio (i.e. SDR 5 or SDR 6) and Nominal Pressure (i.e. PN20)
- Marking the product with the applicable standards designation (i.e. DIN 8077/8078)
- Quality System used ((i.e. ISO 900X)
- Date and time of manufacture reference
- Manufacturer's name and country of manufacture.

2. Polypropylene Fittings

All fittings supplied under this scope of work must be pressure rated (PN20) and manufactured from the same material used to manufacture pipes and shall pass all tests required under DIN 16962/5 and/or PrEN 12202- Part 3.

Fitting Inserts - All inserts used in the manufacturing of threaded fittings must be made of Nickel Plated Brass. All male threads must be serrated to ease the application of sealing tape. Male threaded fittings must have PP-r coverage extending to the outer tip of the insert (on inner surface)

Marking of Fittings- All fittings shall have permanent identification markings indicating the following:

- Trademark, size and pressure rating of fitting (PN20)
- Standard PP-r designation (i.e. PPr80 or PPr-type3)
- Day and Year stamp indicating period of manufacturing
- Manufacturer’s Quality Control

3. Joining Polypropylene Pipes and Fittings

Socket Fusion Joining: This is the predominant process used to join PP-r pipes to PP-r accessories. In this form of joining, which requires heating tools, a pipe end and fitting socket are heated simultaneously to fusion temperature (260 °C) using a heating bush and a heating spigot, and are then pushed together, thus resulting in a homogeneous joint.

Electrofusion Joining: This technique is used strictly for repair and emergency work. In electrofusion, the pipe and electrofusion fitting are heated by means of resistance wires and fused together. Power is supplied through an automatic fusion control unit supplied by the manufacturer of fittings.

Heat Fusion Training Services: Upon request, the Manufacturer shall provide training in the Manufacturer's recommended socket fusion and electrofusion procedures to the Contractor's installation personnel, and to inspectors representing the Owner.

4. System Inspection and Testing

Upon completion of a section of or the entire water supply system, the system, or portion completed, shall be inspected and proved tight under water pressure. The inspection must take place before embedding or concealing the system under concrete or in walls.

For PP-r pipes, the inspection process is broken down in two sections: visual and operational.

Visual inspection: A visual inspection should cover, but not limited to the following basic steps:

- No pipe shall be secured to another pipe or used as a support for other pipes.
- Pipes shall be laid as to prevent the formation of air locks or pockets. Where pipes are laid above one another, cold water pipes shall be installed under hot water pipes to prevent condensation.
- The supply pipes for each floor and those in individual flats shall be capable of being shut separately.
- All inlets and outlets of completed pipe work shall be tightly closed with stoppers or caps to prepare for operational phase of the system inspection.

Operational inspection: The visually inspected pipe work shall be filled with fresh water and completely vented. The presence of air pockets in the system will lead to premature explosive failure of the system with dangerous consequences to human life near the failure point.

The operational phase of the inspection shall be carried out in two stages:

a- First stage: a test pressure equal to the permissible working pressure plus 10 bars shall be produced twice within 30 minutes at 10-minute interval. Then it shall be checked whether, over an additional period of 30 minutes, the pressure has dropped by more than 2.0 bars and leakage has occurred (ambient and testing medium temperatures must be taken in consideration when performing this test, consult with manufacturer for correction factors).

b- Second stage: It shall follow the first stage without interval and shall last 24 hours at a pressure of 15 bars. The system should hold a stable pressure with no variation. An overall drop of 2.0 bars is acceptable if a stable pressure is achieved. Any other behavior indicates a leak.

E) **Galvanized Steel Pipes (GSP)**

Galvanized steel pipes shall be of the welded galvanized steel pipes to ASTM A 120 Schedule 40. All pipe fittings elbows, tees, crosses, unions, reducers, etc. shall be of the same quality and weight as the pipes.

Pipe fittings 2 1/2" (65 mm) and smaller shall be suitable for threaded connections, 3" (80 mm) and larger shall be flanged.

GSP are allowed to be used for fire water piping, and/or as specifically mentioned in the schedule of pipe materials.

F) **Copper Pipes (CuP) Type 3**

Copper pipes shall be of the seamless hard drawn tubing type K or L to ASTM B88. Tubing, to be used, shall have been cleaned by the manufacturer and the open ends capped to preserve cleanliness.

Cup shall be designed, constructed and installed in compliance with ASA B9.1 and ASA B35.5 (safety code for Mechanical Refrigeration).

CuP shall be suitable for solder jointings with forged or wrought copper fittings.

Cast fittings should not be used because they might be porous and allow the refrigerant to leak.

Surfaces to be soldered shall be cleaned bright. The joints shall be given a thin coating of approved soldering flux and the tubing end inserted into the fitting as far as possible.

Heating and finishing of the joint shall be done in accordance with the recommendations of the manufacturer of the fittings. During the heating, the pipe and fittings must be kept full of an inert gas N or CO2 to prevent formation of scale.

The solder metal to be used shall be a non-ferrous metal or alloy having a melting point below 800 ^{O}F (427 ^{O}C) and below that of the metal being joined, an accepted solder is Sil- Fos to make copper to copper joints.

When solenoid valves are being installed, the coil should be removed, and no heat shall be applied near the bulb of the expansion valve.

CuP are allowed to be used to carry refrigerants 22, and 134a and/or as specifically mentioned in the schedule of pipe materials.

G) **Black Steel Pipes (BSP)**

BSP shall be black mild steel, seamless type to BS 1387 medium weight or ASTM A-106 GR.B sch.40, and all pipe fittings shall be black forged steel of the same quality and weight as the pipes.

Pipes fittings 2" (150 mm) and larger shall be suitable for welded connections.

All joints shall be welded by an approved welding process, each joint being of sufficient strength to withstand the stresses imposed by internal pressure, thermal expansion and weight of tube, fittings and thermal insulation.

All welded tees, branches, vent pipes, reducers, etc. shall have beveled joints, and finished off with a circumferential butt joint weld.

Welding of pipe work may be by either oxy-acetylene or electric process.

BSP are allowed to be used for heating water piping, exhaust manifold, fuel oil pipes and/or as specifically mentioned in the schedule of pipe materials.

H) **Multilayer Pipes**

Multi-layer pipes shall be of the diffusion 5 layers composite type, with a longitudinally overlapped welded aluminum with the inner and outer layers made of cross-linked polyethylene tightly bonded to the aluminum by means of adhesives:

Permanent load up to:	max. 95 ^{0}C/ 10 bars
Peak load:	max. 110 ^{0}C/ 10 bars
Pipe roughness:	0.0004 mm
Thermal conductivity:	0.40 w (mk)
Thermal expansion coefficient:	25 x 10^{-6} m/mk

All fittings shall be nickel-plated brass type to DIN 1988. Fittings shall be manufactured by the same pipe manufacturer.

1.07 **PIPE JOINTS**

A) **Flanged Pipe Joints**

- All flanged joints shall be made up with compressed ring type gaskets. Gaskets shall be 1.5 mm. thick.

- Bolts for flanges shall be of low carbon steel with hexagonal heads and hard pressed steel hexagon nuts. Bolts shall be to ASTM specifications A 307 or SAE grade 2, with tensile strength of 64000 psi (441.3 Mpa) minimum.

- All bolt holes shall be spot faced.

B) **Joints Between Dissimilar Materials**

- Screwed Pipe to Cast Iron Pipe

  Joints between wrought-iron, steel, brass or copper pipe and cast iron pipe shall be made with cast iron spigots screwed to the steel pipe and caulked to the cast iron pipe.

- Copper Tubing to Screwed Pipe Joints

  Joints shall be made by the use of brass converter fittings. The joint between the copper pipe and the fitting shall be properly soldered, and the connection between the threaded pipe and the fitting shall be made with a standard pipe size screw joint.

C) **Joints Between Dissimilar Metals (Dielectric isolators)**

- Make joints between ferrous and non-ferrous screwed piping and equipment by using Teflon or nylon isolating materials in the form of screwed unions, as manufactured by the Capital Mfg. Co. or by EPCO. Sales Co.
- Make joints between ferrous and non-ferrous flanged piping and equipment with Duriron Co., Inc., "Task-Line" insulating gaskets and "Teflon sleeves and washers between flanges, bolts and nuts.
- The entire insulating joint including the dielectric material shall be suitable to withstand the temperature, pressure and other operating characteristics for the service for which they are used.

1.08 **PIPING SCHEDULE.**

A) **General**

Piping classes are specified for each service in the following schedule. The designations indicated refer to detailed specifications for piping in this section of the specifications:

B) **Piping Classes**

Service	**Piping Class**
- Domestic cold & hot water supply inside Pump Rooms and on Roof.	PP-r
- Domestic cold & hot water supply elsewhere	PP-r
- Storm drain above ground	PVC Type 1
- Fuel Oil	BSP

-	Drainage pipes	PVC Type 1
-	Main Heating Water Pipes	BSP
-	Heating Water Pipes Under Tiles	Multilayer
-	A/C Condensate drain	PVC Type 2
-	Refrigerant	CuP type 3
-	Boiler fume exhaust	BSP
-	Drainage pressure pipes	PVC Type 2

1.09 VALVES

A) Description of Work

The work included under this part shall consist of valves and fittings, as hereinafter specified and as shown on the Drawings. Such work shall include, without being limited to items described in the following clauses.

B) General Requirements

- Valves shall be installed only in vertical or horizontal positions unless otherwise required by the Drawings.
- All valves shall be installed in accessible locations to facilitate easy removal for maintenance.
- Valves shall be full-line size.
- Valves 2 1/2" (65 mm) dia. and smaller shall have threaded ends, valves 3" (80 mm) dia. and larger shall have flanged ends.
- All threaded end valves shall be installed with unions to facilitate the removal of the valve from the pipeline.
- Gate valves shall be installed on both sides of every piece of equipment for all pipe-system connections, and where shown on the Drawings.
- All valves shall be designed for a working pressure of 125 psi (860 Kpa). Except for fire fighting application, working pressure shall be 175 psi (1210 Kpa).

C) Tests

All valves shall be tested in accordance with the appropriate section of the Specifications describing each system.

D) **Gate Valves**

Gate valves up to 2 1/2" (65 mm) shall be all bronze, screwed ends, non rising stem, screwed bonnet, solid wedge disc type.

Gate valves 3" (80 mm) and larger shall have cast iron body, non-rising stem, flanged ends, bolted bonnet and bronze wedge disc faces and seats.

One gate valve shall be supplied and installed:

- At the supply and return from each equipment.
- At the discharge and suction of each pump.
- At the bottom of each riser and all low points to be drained.
- In general at all points shown on the drawings and/or specified.

E) **Globe Valves**

Globe valves, 2 1/2" (65 mm) and smaller, shall be all bronze, screwed ends, rising stem, screwed bonnet renewable composite disc and seat.

Globe valves 3" (80 mm) and larger, shall be cast iron, flanged ends rising stem, bolted bonnet, renewable composite disc and seat.

F) **Check Valves**

Check valves 2 1/2" (65 mm) and smaller, shall be all bronze, screwed ends, screwed cap with horizontal lift check, renewable composite disk and seat. Valves 3" (80 mm) and larger, shall be cast iron, flanged ends, bolted cap with swing check, renewable composite disc and seat.

One check valve shall be installed:

- At the discharge of each pump.
- At all points shown on the drawings and/or where specified.

G) **Double Regulating Valves**

Double regulating valve shall be of the Y-pattern bronze globe valves, it shall have a characterized throttling disk with sufficient authority to regulate flow in a circuit incorporating a Flow Measurement Valve. The valves shall have a unique device, which enables the disk to be locked in position to control flow at a pre-determined rate. An Allen key (3mm) shall be supplied for lock adjustment. Tight closure of the valve shall be assured by use of a PTFE disc insert. The valves shall be rendered 'tamper proof'. An in-built drain valve shall be used for draining, back filling or air venting.

H) **Float Valves**

Supply and install all float valves as shown on the drawings and wherever specified in this book of specifications.

Float valves 2 1/2" (65mm) and smaller shall be all bronze, screwed ends, float operated. Valves 3" (80mm) and larger shall be cast iron body, flanged ends, float operated. Float shall be all copper and mounted at the end of a brass or copper rod, which actuates valve operation.

I) **Automatic Air Vents**

Supply and install all automatic air vents as shown on the drawings and wherever specified in this book of specifications.

Automatic air vents of the spherical float type shall be installed at all high points in the piping. Vents shall have cast iron housing and bolted cover with gasket. Float shall be constructed of stainless steel. Vents shall be suitable for a maximum operating pressure of 150 psi (1030 Kpa). A 1/2" (15 mm) lock shield valve shall be directly installed ahead of each automatic air vent, and a 1/2" (15 mm) drain line shall be provided to discharge at a convenient point.

J) **Temperature and Pressure Relief Valve**

- This valve shall be used on domestic hot water lines wherever applicable.

- Temperature and pressure relief valve shall be self-closing type with test lever and screwed connections.

- Valve shall be suitable for a pressure of 75 to 150 psi (520 to 1030 Kpa) service and shall be supplied with temperature relief set at 210 ^{O}F (100 ^{O}C).

- Valve shall be AGA and ASME rated and similar to watts Regulator Co. or approved equal.

K) **Pipe Expansion Joints**

Supply and install expansion joints wherever pipes cross structural expansion joints, and wherever required to prevent undue stresses caused by thermal expansion of the pipes.

Expansion joints shall be of the packless-bellow type with flanged or welded ends as suitable for the pipe application.

Bellows shall be of stainless steel and suitable for a pressure of 125 psi (860 Kpa) or the design working pressure, whichever is greater. Expansion joints shall be provided with guides to prevent any unnecessary misalignment of the pipe. Guides and anchor arrangements shall be per the recommendations of the expansion joints manufacturers.

L) **Strainers**

- Water strainer shall be supplied and installed at the suction connection of all pumps, and ahead of all automatic flow control valves.

- Strainers 2 1/2" (65 mm) and smaller shall be Y-pattern type with bronze body, screwed cover, brass basket and screwed ends.

- Strainers 3" (80 mm) and larger shall be of cast iron body, brass basket and flanged ends.

- Basket shall have 1/32" (0.8 mm.) perforations for water service.

- Strainer shall be suitable for a maximum working pressure of 200 psi (1380 Kpa) non-shock.

M) **Flexible Pump Connectors**

- Shall be easy flexing, long cyclic life connectors, to protect mechanical equipment by relieving piping stresses, caused by piping misalignment, sagging pipe hangers, and thermal expansion.

N) **Approved Manufacturers**

- Except where otherwise specified, approved manufacturers for valves specified are as follows:

  - Crane Co.
  - Kennedy Valve Mfg. Co.
  - Walworth Co.
  - Hattersley, Ltd.
  - Serseg.
  - Apco.

- The contractor shall provide the valves specified, as produced by one of the above listed manufacturers or by any other approved manufacturer.

  Approval of a manufacturer does not necessarily constitute approval of his valves. Contractor shall submit to the Engineer, for approval, and before starting construction, a written summary of the valves to be furnished indicating manufacturer, service, catalog number and trim.

- Automatic Air Vents and Pressure Relief Valves

  - Crane Co.
  - Serseg.
  - Metraflex Co.
  - Apco.

- Strainer

  - Crane Co.
  - Zurn Industries Inc.
  - Sarco Co.

- Expansion Joints

  - Metraflex, Inc.
  - Crane Co. Vokes.
  - Teddington - Bellatrix.

- Flexible Pump Connectors

  - Metraflex, Co.

Or approved equal.

1.10 FUEL STORAGE TANKS

- Tank shall be constructed of 6 mm. thick welded black steel sheet metal to the capacities indicated on the Drawings.

- Tank shall be tested for leaks before installation and shall be painted with two coats of red lead oxide or approved equal, and two coats black bituminous paint.

- Tank shall be mounted on a concrete pad and shall be equipped with the following:

  - Manhole and manhole covers air tight.
  - Protected oil level indicator fixed to the tank.
  - Fill and vent pipes.
  - Two gate valves one in fuel supply line and one in drain line.
  - Overflow, drain and supply lines.

1.11 FUEL OIL MISCELLANEOUS ITEMS

A) Fuel Oil Strainers

Y-pattern, full size of connecting piping. Include Type 304 stainless steel screens with 1.2 mm perforations.

1. Pressure Rating: 860 kPa (125 psig) minimum steam working pressure.

2. Size 65 mm and Smaller: Bronze body, with female threaded ends.

3. Sizes 80 mm and Larger: Cast-iron body, with flanged ends.

4. Screwed screen retainer with centered blow-down and pipe plug.

B) **Fuel Oil Solenoid Valves**

- Fuel oil Solenoid valve shall be 2 way, 2 position motorized valve providing open-closed control of Diesel oil flow through operation of motor actuator and valve linkage in response to signal from an off-on switch.

- Single seated valve, straight-through pattern; screwed end connections, bronze body and removable brass seat on 15 to 40 mm sizes; flanged end connections, cast iron body and removable bronze seat on 50 to 80 mm sizes; stainless steel stem and composition disc with removable throttling plugs

- Reversing type motor, with oil-immersed gear train, die- cast aluminium case, dual-stroke (90 and 160 degrees), double-ended crankshaft and die-cast aluminium cover with built-in transformer

- linkage directly mounted on motor, without adjustment requirements and comprising roller, slide mechanism, cam and stem position indicator and with 160 lb. seal-off force

- Valve rated 240 deg. F maximum fuel oil temperature and 125 psi maximum pressure for flanged end connections and 150 psi for screwed end connections

- Motor rated 125 deg. F maximum ambient temperature.

C) **Approved Manufacturers**

Fuel Oil Piping Specialties:

a) Emco Wheaton, Inc.
b) A.Y. McDonald Mfg. Co.
c) OPW Fueling Components Group, Dover Corp.
d) Preferred Utilities Manufacturing Corp.
e) Universal Valve Co., Inc.

or approved equal

1.12 PUMPING EQUIPMENT

A) Description of Work

The work included under this section shall consist of pumping equipment and accessories as hereinafter specified and as shown on the Drawings. Such work shall include, without being limited to items described in the following clauses of this section.

B) General Requirements

- Pumps shall be mounted on bases with isolating pads as specified in the specification.
- Pumps and motors shall be aligned and leveled throughout the length and width, and wherever necessary, suitable shims shall be provided to facilitate pipe connections and leveling.
- Pumps shall be secured to bases with proper size anchor bolts.
- Drains for packing glands and base shall be piped to nearest drain outlet.
- The designed pump head indicated on the drawings is only approximate and the Contractor shall confirm the exact head of the pumps after all the equipment selections and the shop drawings are approved.
- The Contractor shall submit for approval and prior to shipment all detailed construction drawings showing exactly in place all pumps with their concrete bases, vibration isolators, pipe connection and power connections.
- Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.
- Where corrosion can occur, appropriate corrosion-resistant materials and assembly methods must be used including isolation of dissimilar metals against galvanic interaction.
- Provide shaft packing or seals compatible with the pump design, and in accordance with the manufacturer's recommendations.
- Pump manufacturers should take particular note of the suction head pressure required for each pump so as to provide casings, seals, and overall pump construction to withstand the high pressure required for some pumps.
- Provide casing connections for vents, drains, suction and discharge pressure gauges.
- Balance impellers and all other moving components statically and dynamically.

- Grout base plates completely to provide a rigid non-deflecting support.

- Install packing rings with alternate layers staggered 90^{o}. Tighten packing for seal while permitting prescribed amount of leakage.

- Install and align mechanical seals in accordance with the manufacturer's recommendations.

- Each pump shall be provided with pressure gauges at suction and discharge sides.

- All pumps shall be designed to operate with non-overloading characteristics at manufacturer's specified RPM.

- Coupling guards shall be provided to all pumps.

- All pumps shall be as much as possible selected from one pump manufacturer.

C) **Pump Settings**

- All pumps and motors shall be properly set, leveled, and aligned on bases and foundation pads in strict accordance with the manufacturer's instruction and their recommended tolerances. This shall be done before any piping or electrical connections are made.

- After all connections have been made, and just prior to putting each pump into operation, it shall be checked again for levels and alignment.

- All necessary adjustments shall be made to assure that the thrust is balanced, that shaft rotates freely when turned by hand and that pump is quiet in operation.

D) **Tests**

- Pumping equipment shall be tested for operating characteristics, and duration of test shall be set by the Engineer. Apparent defective equipment shall be repaired or replaced and adjustment made to the equipment as may be necessary, all to the satisfaction of the Engineer.

- Before shipment, the manufacturer shall test all components hydraulically at 150% of rated working pressure for ability to withstand maximum design pressure and for tightness.

- Upon completion of the installation, test all equipment under field operating conditions to demonstrate capability of the equipment to meet specified requirements. Compile and certify the following data.
  - Water flow, GPM (l/s) at rated head.
  - Shut-off head.
  - Operating Kilowatts from measured voltage, amperes and power factor.

E) **Operating Characteristics**

- Pump operating characteristics shall be in such a way when operating at the speed specified the pump motor will not be overloaded no matter what the variation in pumping head.

- Pumps must operate without any pulsation, vibration, or internal recirculation. Pump characteristics shall be such that a variation of 10% in the head will result in no more than a 15% variation in water pumping rate.

- Pump shall be selected so that the operating gpm is just below, and to the left of, the gpm corresponding to the peak horsepower for the pump operating at design speed.

- Performance curve data sheets shall be provided with Shop Drawings for each type and size of pump submitted for approval.

- The closed discharge head for all pumps shall not exceed the working head by more than 25%.

- The pump motor shall be sized so that it operates continuously throughout the performance range of the pump without exceeding the nameplate rating of the motor.

1.13 **PUMPING UNITS**

A) **Vertical Multi Stage Centrifugal Pump**

Supply and install wherever shown on the drawings horizontal or vertical multistage high pressure centrifugal pumps of capacities as indicated in the capacity schedules and/or shown on the drawings.

Pumps and motors shall be mounted on a heavy cast iron drip base, and connected through a heavy duty flexible coupling.

Pump shall have cast iron casing and bronze impellers statically and dynamically balanced. Shaft shall be of carbon steel with bronze sleeves and mechanical seal.

Each pump set, for domestic water supply application, shall be complete with the following:

* Electric control panel complete with circuit breakers, earth leakage protection as required by the Authorities, Phase failure protection, starters, automatic electric alternators, indicating lights and selector switches. Panel shall be made of sheet steel of dust and splash proof to minimum IP 54 type with lockable door.

* Panel and door shall be rust proof.

* Level switches, installed in both domestic water reservoirs, (in basement and roof) and control cables between the level switches and the electric control panel.

Pump speed shall be as shown in the pump schedule.

B) **End-Suction Pumps**

- General

Supply and install wherever shown on the Drawings end-suction centrifugal pumps of capacities as indicated in the capacity schedule and/or shown on the Drawings.

Each pump shall be of the type specified and shall be directly coupled to an electric motor and mounted on a common steel base plate.

Pump casing shall be of the close-grained, high tensile strength gray iron, with smooth water ways and fitted with bronze wear ring. Impeller shall be bronze, enclosed, accurately machined and statically and dynamically balanced. Shaft shall be one piece stainless steel with bronze sleeve of ample size to carry any axial and radial thrust.

Pump shall have mechanical shaft seal of extra hard carbon and ceramic type.

Pump ball bearings shall be of ample size to withstand all axial and radial thrust.

Pump speed shall be as shown in the pump schedule.

Method of Control of Pumps used for Water Supply application

- One pump shall act as a standby (as indicated in the pump schedule)
- A low water level float switch installed in the lower water tank shall prevent either of the pumps to run dry if the lower tank is empty.
- A float switch installed in the roof water tank with two predetermined levels. The high level when reached shall stop the pump automatically and the low level when reached shall start the pump automatically.
- An electric alternator shall alternate the duty and standby pumps on every cycle. In case of failure of duty pump to start, the standby shall be automatically started.

C) **In-Line Centrifugal Pumps**

Supply and install pumps with capacities as shown on plans. Pumps shall be in-line type, close-coupled, single-stage design for installation in vertical or horizontal position, and capable of being serviced without disturbing piping connections.

Pump casing shall be of cast iron. The impeller shall be of cast bronze, enclosed type, dynamically balanced, keyed to the shaft and secured by a locking capscrew.

The liquid cavity shall be sealed off at the motor shaft by an internally-flushed mechanical seal with ceramic seal seat and carbon seal ring, suitable for continuous operation at 225 deg. F. A bronze shaft sleeve shall completely cover the wetted area under the seal.

Motor shall meet NEMA specifications and shall be size, voltage called for on the plans. It shall have heavy duty grease lubricated ball bearings, completely adequate for the maximum load for which the pump is designed.

D) **Hot Water Circulators**

Supply and install wherever shown on the drawings hot water circulators of the centrifugal in-line type directly coupled to an electric motor suitable for handling hot water at 200 ^{O}F (93 ^{O}C).

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 motor and maintain its thermostat setting.

E) **Submersible Pumps**

Supply and install submersible sewage pumps where shown on the Drawings and of indicated capacities and heads.

The pump and motor housing form a compact integral unit and shall be of the completely submersible type. The motor shall be cooled by the fluid in the sump.

The pump/motor housing shall be complete with:

- Lifting Yoke.
- Electrical terminal board, and submersible electric flexible cable between pump motor and control unit.
- Ball bearings good for three years continuous operation.

- Stainless steel shaft with precision ground finish.
- Stator, cast iron stator housing and class F stator insulation.
- Rotor.
- Statically and dynamically balanced non-clog impeller with a minimum passage cross-section of 2 1/2" (65 mm).
- Cast iron pump housing.
- Base and Strainer.
- Tungesten carbide shaft seals to withstand heavily contaminated liquid.
- Gate valve and check valve at pump discharge.

The wet well housing the pump/motor assembly shall be complete with the following accessories:

- Grouting-in cast iron frame with cast iron cover plate and upper guide rail bracket.

- Cable holder to collect power cables and permit adjustment of height of level regulators.

- Discharge connection with lower guide rail bracket.

- Automatic control unit with level regulators to start and stop the pumps automatically. The control unit shall also alternate the operation of the pumps to equalize their operating time. In case of failure of one pump; the control unit shall initiate an alarm and automatically start the other pump.

  A high level float switch, when reached shall automatically initiate an alarm.

  The level regulators (float switches) shall be of polypropylene housing with eccentrically positioned lead weight, mercury switch and 13 meters water proof cable.

  The control unit shall be complete with circuit breakers, starters, automatic electric alternator, indicating lights and selector switches.

F) **Approved Manufacturers**

- Grundfos Pumps
- Flygt
- Goulds Pump
- KSB Pumps.

or approved equal.

1.14 VIBRATION ISOLATION & EQUIPMENT BASES

A) Description of Work

The work shall include the supply, installation and testing of a complete system of vibration isolation to dampen and eliminate all structure borne vibration produced by the electro-mechanical equipment as described here-in below and as detailed on the drawings. Supporting reports on documents with a full vibration analysis study, recommendation and implementation plan from a recognized specialist shall be submitted to the consultant for approval. Such a study shall be submitted at the time the equipment are submitted for approval. The cost of the study, implementation, erection and any rectification to the design shall be done at the contractors own price and without additional cost to the contract value.

B) General Requirements

- The Contractor shall prepare all necessary drawings and sketches showing exactly in place all anchor bolts, drains, or any other required opening, which is deemed necessary for the proper installation of the equipment. These drawings shall be submitted to the Engineer for approval prior to construction.
- The vibration isolators shall be positioned in accordance with the manufacturer recommendations for the equipment load distribution.

The equipment shall be loaded exactly over or between the mounts with no overhang.

- Static deflection of the vibration isolators shall not be less than that recommended in the ASHRAE Handbooks.
- The vibration isolators shall be treated against corrosion. The steel components shall be PVC coated. The nuts, bolts and washers shall be zinc-electro plated.

C) Tests

Brackets and hangers shall be tested to sustain a load of eight times the actual operating load.

D) Isolation Hangers

Isolation hangers shall be used for suspended pipes and equipment. Isolation hangers are rubber or springs or a combination of both.

- Rubber Hangers

Shall be of the rubber-in-shear type. It shall consist of:

- A high grade rubber block with suspension rod and an outside steel housing.
- The steel housing will be anchored to the ceiling slab and the suspension rod shall support the equipment.
- The rubber shall be protected against corrosion due to oil or other damaging agents.

- Spring Hangers

  Shall be of the open mounting type and shall consist of a steel spring between a top and bottom plate with an adjustment bolt for leveling.

  The spring should be designed to provide horizontal stiffness at least 75% of vertical stiffness to assure stability, 50% travel beyond rated load and safe solid stresses.

E) **Isolation Mounts**

Isolation mounts shall be used between equipment and concrete base and at the loading points of the equipment as recommended by the manufacturer.

- Rubber Mounts

  Shall be of the rubber-in-shear type with a cub shape and integrated ribbed rubber pad.

  The pad shall have two boltholes for isolator anchorage to concrete base.

- Spring Mounts

  Shall be of the restained steel spring mountings and shall incorporate hold down bolts to limit vertical movement.

  The isolator shall include an acoustical barrier of rubber pad bonded to the base plate to prevent transmission of very high frequency vibration and noise and be corrosion protected when installed outdoors.

  The spring should be designed to provide horizontal stiffness at least 75% of vertical stiffness to assure stability, 50% travel beyond rated load and safe solid stresses.

F) **Concrete Foundation Blocks**

A reinforced concrete foundation block for each piece of equipment shall be constructed of minimum thickness as shown on the drawings, with a minimum weight equal to at least two times that of the equipment and in accordance with the recommendations of the equipment manufacturer.

G) **Vibration Isolators**

- All piping connected to rotating machinery shall be supported by hangers and supports including vibration isolators.

- Single or double neoprene or rubber-in-shear suspension type within a steel housing. Minimum static deflection 2" (50 mm).

SUB-SECTION 1508

CONTROLS AND INSTRUMENTS

1.01 SCOPE OF WORK

The contractor shall supply and install all the control equipment, auxiliary devices, instruments, etc. to perform satisfactory operations of all systems described in the specifications and/or indicated on the drawings. The drawings and the specifications are complemented each to the other. The sequence of operation of each system or piece of equipment is specified either under the equipment specification section or detailed on the drawings.

1.02 GENERAL REQUIREMENTS

- Control system shall be of the electric, or electronic, (solid state) or a combination of them to provide the required sequence of operation.

- Provide all relays, switches, gauges, sources of electricity and all other auxiliaries, accessories and connections necessary to make a complete operable system.

- Install controls so that adjustments and calibrations can be readily made.

- Unless otherwise noted, install all wall mounted thermostats 1400 mm above the floor, measured to the centerline of the instruments.

- Insertion type thermostats shall have adjusting head at eye level, wherever practicable, for adjustment and calibration.

- Install all control valves horizontally with the power unit up.

- Unless stated otherwise temperatures shall be controlled within plus or minus 2 ^{O}F (1 ^{O}C) and humidity within plus or minus 5 per cent of the set point.

- Provide positive positioner devices on all controls operated in sequence and/or where specified or required to maintain the set point within the required limits without override.

- After completion of installation, all automatic controls shall be regulated and adjusted and placed in complete operating conditions subject to the approval of the Engineer and a maintenance brochure including all operating instructions, specifications and sheets for all instruments shall be submitted by the Contractor.

- Electric control systems shall conform to the requirements shown on the Drawings and shall effect the operation of the air conditioning systems contemplated by the design.

- After all controls, valves and motors have been connected, test the systems in the presence of the Engineer to demonstrate the capability of each automatic control system to meet contract requirements.

- Basic components shall be standard catalogue products of single reputable Manufacturer.

- Do not duplicate factory furnished controls of unitary equipment like refrigeration machines, fan coil units, etc. but modify them to conform to these specifications:

  Obtain from the manufacturer of unitary equipment, and submit written certification that proposed control circuit modifications do not conflict with or invalidate Manufacturer's equipment warranty.

- Instrument wire shall be run in conduits separate from other types of wiring and shall terminate on identified terminal strips.

- The wire terminals on instruments shall not be used as junction points to facilitate removal of instruments without disturbing others.

- Instruments shall have laminated plastic nametags with tag numbers and service engraved on the tag. Tags shall be securely fastened to the instrument. Tags shall be black with white lettering.

- The equipment shall be restarted after a power failure in the same sequence and with the same time delays as specified for normal start-up.

1.03 CONTROL PANEL AND CONTROL SYSTEM

- Control panels shall be installed where shown and as required on the Drawings. Each panel shall include start-stop and pilot lights for all major equipment being controlled together with their starters and necessary heat detector, alarm and other related safety and fire alarm systems.

- The control system shall be complete with all necessary transformers, thermostats, valves, dampers, damper operators, and associated regulators required to maintain the conditions desired together with the thermometers, gauges, and other necessary accessories and the control wiring.

- Shop drawings shall be schematic diagrams showing all the components of the control systems and the interconnection scheme. Each component shall be identified by name and/or schedule number of equipment item it controls.

- Manufacturer's detailed Shop Drawings, specifications, and data sheets for all equipment to be furnished shall be submitted to the Engineer for approval.

1.04 **CONTROL DEVICES**

D) **Room Thermostats**

- Shall have metal locking covers and shall be provided with concealed adjustment means, and with thermometers.

  Each room thermostat shall be supplied with metal auxiliary mounting bases and metal subbase for surface mounting applications; plus a plastic guard to protect thermostat from damage.

- Line voltage on/off thermostats shall be of the bimetal operated snap action switch. They shall be underwriters' laboratories inc., listed at an electrical rating appropriate to the application. Thermostat shall operate on 2 ^{O}F (1 ^{O}C) differential and shall have a control dial range 55-85 ^{O}F (13-29 ^{O}C).

- Low voltage thermostats shall be of the self contained type with a 1000 ohm sensing element and an amplifier. Thermostat shall have a control dial range 55-85 ^{O}F (13-29 ^{O}C) and a throttling range of 2 ^{O}F (1 ^{O}C) for a 3 Vdc output change.

1.05 **THERMOMETERS AND GAUGES**

A) **General**

Mount pressure gauges directly at the sensing point unless otherwise indicated.

Select the instrument so that the normal range of operating temperatures and pressures falls within the middle-third of the instrument range. Use compound gauges when normal operating pressure is near or below atmospheric.

Locate temperature sensing devices in a portion of the fluid stream where it will measure the average fluid temperature without obstructing flow. Increase pipes 1 1/2" (40 mm) in diameter and smaller at least one pipe size at the point of insertion.

Where thermometer sensing bulbs are inserted in air ducts or casings, provide perforated bulb housing with a 3" (80 mm) diameter union flange to permit removal. Connections for sensing elements are to be brass except where otherwise specified. Provide all thermometers in piping systems with stainless steel wells and 3/4" (20 mm) separable sockets.

Provide extension necks where thermometers and pressure gauges are located in insulated piping, vessels, ductwork, casings or equipment.

All thermometers and gages shall have both English and metric units gradings.

B) **Thermometers**

Permanently installed thermometers shall be mercury-in-steel dial type 150 mm diameter having a suitable length of copper covered steel capillary tubing to connect the dial with the bulb, shall be supplied and installed as specified and as approved by the Engineer. Each thermometer shall be provided with back flange or arranged for flush mounting.

Mercury-in-glass type thermometers with metal guard shall be supplied and installed as specified or as approved by the Engineer.

Unless otherwise specified, thermometer bulbs shall be of steel type, screwed 3/4" (20mm) British Standard pipe and supplied with stainless steel separable pockets suitable for screwing, brazing or welding into the pipe carrying the medium to be measured.

Thermometers shall be tested to read alike on the midscale band, with their bulbs immersed in water, and the discrepancy between the highest and the lowest thermometer shall not exceed 0.5 ^{o}C.

A red mark on each thermometer scale shall indicate the working temperature at the point of measurement.

Thermometers shall be marked in both Degree C and Degree F.

C) **Pressure Gauges**

Bourdon-tube type with 120 mm diameter cast aluminum case with moisture-proof and dustproof blowout discs. Panel mounted gauges to have steel or aluminium hinged rings; direct mounted gauges to have back flange, black numerals on a white background face.

Pressure gauge shall be furnished with a lever-operated gauge cock, and shall have snubbers installed between the gauge cock and the gauge to eliminate pulsations.

Bourdon Tube shall be Phosphor bronze, (beryllium copper bellows).

Socket shall be Stainless steel.

Accuracy shall be at least 1% of scale range, range shall be equal to twice the rated working pressure of the unit (pumps, chillers, etc…) reading shall be in psi and Kpa.

Gauges for combined pressure and vacuum service to have compound seal.

D) **Gauge Test Points**

Gauge test points for temperature and pressure of flow shall be installed in all systems and particularly pairs of valves for regulating mains at flow and return connections to all plant and at all thermostatic elements and sensors.

Pressure gauge test points shall consist of 6mm. bore bosses in the pipe work fitted with a test cock and plugged off.

Airflow test points shall be provided in the air ducting at all branches and regulating dampers adjacent to each plant item and automatic control element at all fan inlets and discharges and elsewhere as required.

Test points shall consist of a 40mm. diameter hole drilled through the ducting and covered with a removable spring clip fastened cover.

K) **Ammeters**

One 100 mm dial ammeter shall be supplied for each motor 10 HP (7.5KW) or larger, and for all electrical apparatus fed from the control panel. Ammeter shall be red lined at the normal running load.

L) **Voltmeters**

One 150 mm dial voltmeter shall be supplied to indicate the voltage of the motor control center in each Plant-Room.

The Voltmeter shall be complete with a seven-position, rotary switch to enable reading the voltage between all phases and neutral.

1.06 **APPROVED MANUFACTURERS**

- Automatic Controls:
  - Honeywell.
  - Barber-Colman Co.
  - Johnson Controls Inc.
  - I.T.T Controls.

  or approved equal.

SUB-SECTION 1509

INSULATION AND LAGGING

1.01 SCOPE OF WORK

- Supply and install all insulation and lagging on piping or vessels as indicated on the drawings or specified to be insulated.

1.02 GENERAL REQUIREMENTS

- General

  - All insulation shall have a smooth, homogenous and lineable finished surface. All rigid sections shall be concentric and be accurately matched for thickness.

  - All surfaces to be insulated shall be dry and free from loose scale, dirt, oil or water when insulation is applied.

  - Insulation shall be applied in such a manner that air circulation within the insulation or between the insulation and the pipe shall be avoided.

  - No surface imperfections in the insulation such as damaged edges, or ends, cracks and small voids or holes shall be accepted.

  - Insulation materials shall be stored and protected from weather moisture, accumulations of foreign matter, or possible damage in a dry and clean store.

  - Canvas jacket, where used, and all insulating materials shall be non-combustible, or self-extinguishing non-flame spread grade.

  - Surface finishes and lagging adhesives shall not be diluted and shall be applied in accordance with the manufacturer's instructions.

  - Apply insulation to permit expansion or contraction of metal without causing damage to insulation or surface finish.

- Piping Insulation - General Provisions

  - All pipe covering shall fit snugly on the pipe to which it is applied. Inside circumference of pipe covering when applied shall not vary from the outside circumference of the pipe by more than 3mm. undersize.

  - Pipe insulation shall have factory applied jackets and secured with plastic bands at each joint at center of each section and where sections abut upon fittings, except where otherwise specified.

  - Insulation shall only be applied to piping after all testing has been accomplished and after all the coats of paint have been applied.

  - Pipe covering shall be terminated at a sufficient distance from all flanges to permit easy removal of bolts.

  - Sufficient time shall be allowed to permit complete dry out of insulation at flanges or openings in insulation as well as of all cement before sealing them up.

  - Insulation on flanges and flanged fittings shall consist of a layer or layers of pipe covering or block insulation extending across and overlapping the adjacent pipe covering at least 50mm. The outside of the insulation shall be given a trowelled coat of finish cement to present a smooth surface.

  - Screwed, soldered, and welded fittings and valves (up to the bonnet) on 4" pipe and larger, shall be insulated with block insulation or pipe covering and shall be given a trowelled coat of finish cement to present a smooth surface. Valves for the heating water shall be covered to the gland.

  - Screwed, soldered, and welded fittings and valves (up to the bonnet) up to 4" in size shall be covered with field fabricated mitered segments of pipe insulation equal in thickness to the adjoining insulated pipe and finished with standard weight canvas jacket. Where hangers are installed on the pipe covered with insulation the entire hanger up to the rod shall be insulated.

  - Where insulated piping is subject to movement and supported on roller hangers, steel protection saddles shall be provided and welded to the pipe. Saddles shall be filled with rigid insulation.

  - All insulated piping not supported on roller hangers and subject to movement, shall be provided with protection shields at all hanger locations. Shields shall be of 3mm. galvanized iron extending on each side of the hanger for a distance equal to the diameter of the insulation and shall extend up the sides of the insulation to the center of the pipe and shall be provided with cork pad support.

- Special care shall be exercised in insulating heating water and refrigerant lines to prevent sweat leaks at piping hanger locations.

- Where standard insulation shapes are not available, cut, score or miter segmental or flat block to fit contour of pipe, stagger joints of adjoining segments. Fit insulation carefully and secure with wire. Smooth with insulating cement.

- Insulate valves, strainers, fittings and flanges with identical material, density, thickness and finish as the piping insulation. Use premolded insulation material where available, otherwise use shaped block segments wire on with all edges filled with insulation cement or filler.

- Insulate strainers to permit removal of the basket without disturbing the insulation of the strainer body.

- Equipment and Duct Insulation - General Provision

  - Curved or cylindrical equipment shall be insulated with blocks or curved segments in one layer for thicknesses of 65 mm or less and two layers for thicknesses of 76 mm or more. The insulation shall be applied with joints staggered and tightly butted together and held in place with bands. Square cornered equipment such as boilers, ducts casings etc… shall be insulated with block insulation protected at corners by metal shields and held in place by bands, carried around the unit over the insulation and fastened tight.

  - Metal anchoring clips shall be welded to the equipment surface so that the band will pass over them and may be wired to them after insulation is in place.

  - For outdoor installation, and as a protection against mechanical damage and weather the finish coat over insulation shall consist of 25 mm hexagonal metal mesh equipment tightly stretched over the insulation and secured to clips, bands or tie wires, 13 mm thick rough coat of insulating cement and 1/4" 6 mm thick coat of finishing cement trowelled smooth and applied after the rough coat is dry and a coat of weather resistant mastic.

  - Any part of equipment that is normally removable for service such as heads of heat exchangers, shall be insulated separately from the equipment.

  - No insulation shall be applied over nameplates.

  - Insulated ducts penetrating fire walls or floors shall be insulated completely thru penetration. Provide fire proof sleeves at fire walls and floor penetration.

  - Duct insulation or lining or any type of covering together with the applied adhesives shall have a flame spread rating not over 25 without evidence of

continued progressive combustion and a smoke developed rating no higher than 50, wherever the duct crosses a fire wall or penetrates a roof slab.

- Duct linings shall be interrupted at fire dampers and fire doors so as not to interfere with the operation of services.

- All duct coverings (insulation, linings, ... etc.) shall meet the requirements of NFPA 90A and 90B.

1.04 **PIPE INSULATION - Type A**

- This type of insulation shall apply to Heating Water Pipes under tiles A/C condensate drain lines and refrigerant lines.

- Pipe insulation shall be closed cell elastomeric type cylindrical form to fit sungly, sectional one piece construction, and shall have and a maximum K-factor of 0.25 Btu.In/ft^2.hr.ºF (0.036 W/m.deg.K) at a mean temperature of 75ºF (24ºC).

- Pipes running exposed on roof or in plant rooms shall be covered with 18 gauge aluminium jacket on top of insulation.

1.05 **PIPE INSULATION - Type B**

- This type of insulation shall apply to Main Heating water lines,

- Pipe insulation shall be performed rigid section fiberous glass molded in cylindrical form to fit snuggly, sectional one piece construction with a min. density of 4 lbs/ft3 (65 kg/m3) and a max. K factor of 0.25 Btu.in/ft2. hr. ºF (0.036 W/m.deg.K) at a mean temperature of 75 ºF (24 ºC). The insulation shall have a factory applied high-density white kraft bonded to aluminium foil, reinforced with fiberglass yarn. The kraft paper shall be chemically treated to assure fire and smoke safety and to prevent corrosion of foil. The insulation shall be applied to the pipe with longitudinal joints staggered. Laps and sealing strips shall be sealed applying fire resistant adhesive or circumferential joints.

- The surface finish shall be secured with aluminium bands, using a minimum of three bands per block.

- All pipes running exposed to view inside the building shall have canvas cover, securely fixed, overlaps firmly, pasted down, secured with aluminium bands at intervals and painted with two coats of fire retardant emulsion paint and one coat of gloss paint to an approved color.

- Pipes running exposed on roof or plant rooms shall be covered with 18-gauge aluminium jacket on top of insulation.

1.06 **EQUIPMENT INSULATION**

- This type of insulation shall apply to boilers, electric water heaters, boiler circulator, pumps, heat exchangers hot water expansion tanks and domestic hot water tanks.

  Insulation shall be semi-rigid fibrous glass with organic binder up in board form with a minimum density of 3 lbs/ft3 (50 kg/m3) and a maximum K-factor of 0.42 Btu-in/ft2.hr.^{O}F (0.06 W/m.deg.K) at a mean temperature of 200 ^{O}F (94 ^{O}C). Insulation shall be applied over pins welded to the vessel on 300 mm centers. All joints shall be staggered and tightly butted. The insulation shall be covered with gauge 18 aluminium jacket.

- This type of insulation shall apply to heating water expansion tanks.

  Insulation shall be flexible elastomeric flat sheets furnished with a smooth skin on the outer side with a maximum K-Factor of 0.27 Btu-in/ft2.hr.^{O}F (0.039 W/m.deg.K) at a mean temperature of 75 ^{O}F (24 ^{O}C). Insulation shall comply with flame spread rate by ASTM E84 test methods.

  Insulation shall be applied over a heavy coating of special adhesive as recommended by insulation manufacturer.

- This type of insulation shall apply to heating water pumps.

  Insulation shall be removable and replaceable covers consisting of No. 18 gauge aluminium sheet metal jacket lined with rigid fibrous glass with a resin binder of a minimum density of 6 lbs/ft3 (96 Kg/m3) and a maximum K-factor of 0.25 Btu.in/ft2.hr.^{O}F (0.036 W/m. deg.K). All voids between insulation and pump housing shall be filled with blanket type fiberglass insulation of 6 lbs/ft3 (96 Kg/m3) density.

  The metal casing shall be tightly sealed.

1.08 **SCHEDULE OF INSULATION THICKNESS**

The thickness of the insulation applied to pipes, ducts and equipment shall be as stated hereinafter.

	Service	**Location**	**Pipe Diameter inches (mm)**	**Insulation Thickness inches (mm)**
-	Boilers, Water heaters, heating hot water pumps	---	---	2" (50)
-	Heating hot Water expansion tanks	---	---	1" (25)
-	Heating water pipes	In conditioned spaces	Up to 2" (50)	1 1/2" (38)

-	Ditto	In conditioned spaces	2 1/2" (65) and larger	2" (50)
-	Ditto	In unconditioned spaces & running exposed.	All sizes	2 1/2" (65)
-	A/C condensate drain pipes	---	---	1/2" (13)
-	Refrigerant lines	---	---	3/4" (19)
-	Fume Exhaust Pipes (Rockwool insulation with 1 mm Aluminum Jacket)	---	---	2" (50)

1.09 **APPROVED MANUFACTURERS**

- Johns - Manville
- Owens - Corning Fiberglass Corp.
- Pittsburg Plate Glass Co.
- Armstrong Cork Co.

or approved equal.

SUB-SECTION 1510

PAINTING

1.01 GENERAL REQUIREMENTS

- Surface requiring prime painting shall be cleaned thoroughly of all rust, loose scale, oil, grease and dirt. Use wire brushes and solution for this purpose.

- No painting shall be applied to damp or frosty surfaces in wet, foggy or freezing weather.

- Paint shall be evenly spread and well brushed out so that there shall be no drops, runs or sagging.

- Shop coated surfaces shall be cleaned thoroughly and retouched where necessary.

- Care shall be taken not to paint controls, label plates, nameplates on all apparatus and non-ferrous refrigerant piping.

- All items that have rusted or corroded in storage or in place shall be recleaned or repainted upon request of the Engineer.

- Finishing coats shall be made in accordance with a color code, based on ASHRAE recommendations after being submitted to and approved by the Engineer.

1.02 MACHINERY

All machinery installed under this contract such as motors, pumps, etc. shall have a shop priming coat of gray lead and oil.

1.03 PIPING

- All uninsulated and unwrapped piping including flanges, bolts and valves in trench, partitions, below tiles, or underground shall be painted with 2 coats of emulsified asphalt. All metal surfaces located within or directly adjacent to fresh air intake louvers, except fresh air dampers shall be painted with 2 coats of emulsified asphalt.

- Paint all exposed uninsulated ferrous piping system components including pipe, fittings, unions, flanges, valves, hangers and supports as follows:

  . Exposed to Outside Atmosphere
  .. Prime Coat: Red lead primer. .. Finish Coat: Ironhide gray metal paint.
  . Not Exposed to Outside Atmosphere
  .. Prime Coat: Red lead Primer, 1.5 to 2.0 mils thick.

1.04 **DUCTWORK**

- The inside portions of all ductwork, which are visible through, registers and grilles shall be painted with one coat of dull black, heat resistant paint.

- Uninsulated ductwork exposed to view: One coat of zinc chromate primer, 1.5 mils thick.

- All metal surfaces such as fresh air dampers located within, or directly adjacent to, fresh air intake louvers: Two coats of gray galvanized steel primer, 1.5 mils thick.

1.05 **IRON WORK**

All ironwork within the building, not otherwise specified such as pipe and duct hangers and supports, and supports for apparatus, shall be prime painted with one coat of red lead.

SUB-SECTION 1511

TESTS

1.01 GENERAL

- All piping and equipment shall be tested as specified under the relevant subsection of the specification.

- Labor, materials, instruments, power etc., required for testing shall be furnished by the Contractor unless otherwise indicated under the particular section of the Specification.

- Test shall be performed in the presence of representatives of the Engineer and such other parties as may have legal jurisdiction.

- In general, pressure tests shall be applied to piping system only, before connection of fixtures, equipment and appliances. In no case shall any piping, fixtures, equipment or appliances be subjected to pressure exceeding the ratings as prescribed by the manufacturers of fixtures, equipment and appliances or accepted engineering standards for piping and fittings.

- All defective work shall be promptly repaired or replaced and the tests shall be repeated until the particular system and component parts thereof receive the approval of the Engineer and authorities having jurisdiction, and at no additional cost to the Employer.

- Any damages resulting from tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer, and at no additional cost to the Employer.

- The duration of tests shall be as determined by all parties having jurisdiction, but in no case less than the time prescribed in each subsection of the specification.

- In the event of any repair or any adjustment having to be made other than normal running adjustment, the test shall be void and shall be repeated after the adjustment or repairs have been made.

- When pipes, valves, equipment etc., are to be covered or embedded 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 items until the termination of the work.

- Three copies of all test results shall be submitted to the Engineer.

1.02 **WATER PIPES**

- Test all piping systems, including valves, fittings and joints under a pressure equal to 100 psig (690 Kpa) or 1 1/2 times the working pressure, whichever is greater.

- Blank off or remove all elements such as traps, instruments, automatic valves, diaphragm valve, relief valves, pumps or any other equipment which may be damaged by test pressure. Open, but do not back seat, all valves.

- Fill the system with water and vent the system at high points to remove air. Maintain the required test pressure for a sufficient length of time to enable complete inspection to be made of all joints and connections and for a minimum of six hours, unless specified otherwise.

- Repair all leaks or defects uncovered by the tests and retest the system.

- After tests have been completed, drain the system and blow out and clean it of all dust and/or foreign matters. Clean all strainers, valves and fittings of all dirt, fillings and debris.

1.03 **REFRIGERANT PIPES**

The test procedure shall be as follows:

- Remove and plug the connection points of any control valves that could be damaged by test pressure, open all the shut off valves including the liquid line solenoid valves, but keeping the compressor suction and discharge valves closed.

- Connect a cylinder of oil-pumped, dry nitrogen to the frontseat port of the compressor discharge valve or the liquid line charge valve. The connection shall be made through valve of a gauge manifold.

- Set the pressure regulator on the nitrogen cylinder at 150 psig and start charging the system to raise its pressure to 150 psig.

- Test all pipe joints for leaks. Small leaks can be detected by applying a soap solution on the joints.

- After test is completed, close the cylinder shut off valve and bleed the test pressure through the unused part of the manifold and then repair all leaks found.

- After repairing all leaks, charge the system with enough refrigerant to raise its pressure to 10 psig, then remove the refrigerant connection and charge enough nitrogen into the system to raise the pressure to 150 psig.

Then check all parts of the system with a halide torch or an electronic leak detector. Leaking refrigerant if small, will color the flame of the torch green, and dense blue if leak is large.

If any leaks are found, relieve the test pressure and repair the faulty areas.

The system shall be recharged and kept for 24 hours under 150 psig pressure.

- After the pressure test is successfully completed, the test pressure shall be relieved and all disconnected valves shall be reconnected, then the refrigerant piping system shall be evacuated by a vacuum pump, connected to as many points of the system as possible, until a vacuum equivalent to 500 microns (65 pa) is registered by a vacuum gauge connected to the liquid line charging valve. Evacuation shall be repeated three successive times. At the third evacuation the system shall stand under vacuum for a minimum of 12 hours.

  After the first evacuation, the system shall be charged with oil pumped dry nitrogen to raise the pressure to atmospheric which will absorb any moisture remaining in the system.

- After the third evacuation is successfully completed, the system is ready for charging.

1.05 **DUCTWORK**

- After completion of duct systems and before insulation is installed, the entire system shall be tested under operating conditions for performance and leakage.

- Total allowable leakage for low pressure ducts sealed in accordance with SMACNA's low pressure duct construction standards, shall not exceed five percent (5%) of the system operating airflow.

- The allowable leakage of high and medium pressure ducts should not exceed 1% of the total system design airflow rate.

- All branches and outlets shall be tested for air quantity, and the total of the air quantities shall be within plus five percent (5%) of fan capacity.

- Volume dampers and splitter dampers shall be tested for proper operation.

- All fire dampers shall be tested for ease of operation by setting fusible link and applying heat to release link.

1.06 BALANCING AND ADJUSTMENT

- All air conditioning and ventilation equipment, ductwork and outlets shall be adjusted and balanced to deliver the specified air quantities indicated, at each inlet and outlet, on the Drawings. If these air quantities cannot be delivered without exceeding the speed range of the sheaves or the available horsepower, the Engineer shall be notified before proceeding with the balancing of air distribution system.

- Operate the cooling systems and make all adjustments in controls and equipment, and complete necessary balancing to deliver not less than the water quantities required for each coil and equipment.

- Adjust all equipment to perform with the least possible noise and vibration consistent with its duty. Quietness of operation of all equipment is a requirement. Any piping, ductwork or equipment producing objectionable noise in occupied space must be repaired or replaced with satisfactory one.

- Operate the air conditioning, ventilating and exhaust systems and make all adjustments in controls and equipment, and complete necessary balancing to deliver within 5% of the air quantities shown on the Drawings at each supply and exhaust outlet.

- After all adjustments and alterations have been made, a final test shall be conducted. The final test shall include total air volume at fan, maximum and minimum outside and return air volume at extreme damper settings, static pressure at fan outlet of all fans.

1.07 PUMPS

The pumps shall be tested as described under the pipe, valves, pumps and accessories Section of the specifications.

1.08 TANKS AND VESSELS

All tanks and vessels shall be tested for leaks under hydrostatic pressure equal to at least 1 1/2 times the specified working pressure and as described in ASME Section VIII DIV 1 for unfired pressure vessels. Following the tests, an inspection shall be made of all joints and connections at a pressure not less than two thirds of the test pressure.

1.09 CONTROLS

All controls shall be tested for proper functioning in accordance with the requirements of the Specification.

1.10 NOISE TESTS

The general basis for acceptability of the installations acoustically is stated herein below. (Tolerance + or - 2 db) at any point 1 meter from grilles, registers and terminal unit of the air conditioning systems.

The external noise level of any air conditioning plant shall be no greater than 55 db at the site boundary and all mechanical plant used in the air conditioning system shall be isolated from the structure of building with not less than 90% isolation efficiency.

1.11 VIBRATION TESTS

All equipment provided shall be inspected to ensure that it is free from excessive vibration. Any minor vibration, which may occur, shall not be transmitted from equipment into or through the supporting or enclosing structure.

Should the Engineer consider that excessive vibration is present, such as to warrant the need for specialist testing apparatus and personnel, then the Contractor shall engage and employ such specialist services at no additional cost to the Employer.

1.12 RELIABILITY TRIAL TESTS

- After finishing the above tests and adjustments, the Contractor shall be responsible for running a reliability trial test for the whole plant installed.

- The whole of the trial of the Heating Plant during the period between the 30th November, and 1st March. The Ventilation trial shall take place at any reasonable time subject to the approval of the Engineer.

- The trial shall last for a period of 7 consecutive days and nights during which time the whole of the plant shall operate continuously, without adjustment or repair to the satisfaction of the Engineer.

- During the reliability trial test, performance tests shall be conducted on the Refrigerating Plant, the Heating Plant and the air handling equipment.

- The test data shall not deviate by more than three percent (3%) from the guaranteed capacity data.

- Temperature readings shall be taken for the entering and leaving air of each air handling unit.

- Should any part of the apparatus or system fail to meet the Contract requirements, it shall be adjusted, repaired or replaced to the satisfaction of the Engineer. The complete performance test shall then be repeated.

- A 'Taking Over Certificate' with or without reservations shall be issued by the Engineer on the satisfactory completion of all the tests, provided that these reservations are of minor importance and will not hinder the satisfactory operation of the Plant.

1.13 ACCEPTANCE TESTS

- As soon as possible after carrying out the Reliability Trial Test, and during the Maintenance Guarantee Period, the Contractor shall carry out, unless otherwise agreed, the Acceptance Test Specified in the relevant American or British or approved equivalent Standard Specifications, as well as much additional tests at Site, deemed necessary by the Engineer, to determine that the Works comply with the Specifications and provided that the Works are put into operation.

- The date of commencement of the above said tests shall be subject to agreement with the Engineer.

- As soon as all tests prescribed in the section are carried out satisfactorily in the opinion of the Engineer, an official statement to that effect (herein referred to as Acceptance Certificate) shall be drawn up in three (3) copies and signed by the Engineer and the Contractor. One copy of the Acceptance Certificate shall be delivered to the Contractor.

1.14 MAINTENANCE AND GUARANTEE

The Contractor shall be responsible for the maintenance of all systems at his own expense for a duration of one year starting from the date of issue of the completion certificate. Maintenance shall include replacement of parts or whole equipment that shows any manufacturing or installation defects during operation.

The Contractor shall guarantee every piece of equipment from any manufacturing or installation defects for a period of one year, starting from the date of issue of the completion certificate.