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Mechanical
Book Of Specifications

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July 2016

SECTION 14 21 00
ELECTRIC TRACTION ELEVATORS

PART 1 GENERAL

1.1 DESCRIPTION

A. This section specifies the engineering, furnishing and installation of complete and ready for operation electric traction elevator systems described herein and as indicated on the contract drawings.

B. Items listed in the singular apply to each and every elevator in this specification except where noted.

C. Passenger Elevators shall be gearless traction type; with Variable Voltage Variable Frequency (VVVF) microprocessor based control system with regenerative drive, single car selective collective automatic, center opening.

1.2 RELATED WORK

E. REQUIREMENTS FOR ELECTRICAL INSTALLATIONS: General electrical requirements that is common to more than one section.

F. LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES (600 VOLTS AND BELOW): Low Voltage power and lighting wiring.

G. Section 26 05 26, GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS: Requirements for personnel safety and to provide a low impedance path for possible ground fault currents.

H. RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS: Conduits for cables and wiring.

J. LOW-VOLTAGE TRANSFORMERS: Low voltage transformers.

1.3 QUALIFICATIONS

A. Approval by the Contracting Officer is required for products and services of proposed manufacturers, suppliers and installers and shall be contingent upon submission by Contractor of certificates stating the following:

1. Elevator contractor is currently and regularly engaged in the installation of elevator equipment as one of his principal products.
2. Elevator contractor shall have three years of successful experience, trained supervisory personnel, and facilities to install elevator equipment specified herein.
3. The installers shall be Certified Elevator Mechanics with technical qualifications of at least five years of successful experience and Apprentices actively pursuing certified mechanic status. Certificates shall be submitted for all workers employed in this capacity.
4. Elevator contractor shall submit a list of two or more prior installations where all the elevator equipment he proposes to furnish for this project functioned satisfactorily to serve varying traffic and material handling demands. Provide a list of projects that have the equipment in operation for two years preceding the date of this specification. Provide the names and addresses of the projects and the names and telephone numbers of the projects Administrators.

B. Approval of Elevator Contractor's equipment will be contingent upon their identifying an elevator maintenance service provider that shall render services within two hours of receipt of notification, together with certification that the quantity and quality of replacement parts stock is sufficient to warranty continued operation of the elevator installation.

C. Approval will not be given to elevator contractors and manufacturers who have established on prior projects, either government, municipal, or commercial, a record for unsatisfactory elevator installations, have failed to complete awarded contracts within the contract period, and do not have the requisite record of satisfactorily performing elevator installations of similar type and magnitude.

D. All electric traction elevators shall be the product of the same manufacturer.

E. The Contractor shall provide and install only those types of safety devices that have been subjected to tests witnessed and certified by an independent professional testing laboratory that is not a subsidiary of the firm that manufactures supplies or installs the equipment.

F. Welding at the project site shall be made by welders and welding operators who have previously qualified by test as prescribed in American Welding Society Publications AWS Dl.1 to perform the type of work required. Certificates shall be submitted for all workers employed in this capacity. A welding or hot work permit is required for each day and shall be obtained from the COTR of safety department. Request permit one day in advance.

G. Electrical work shall be performed by Licensed Electricians as requirements by NEC. Certificates shall be submitted for all workers employed in this capacity.

1.4 APPLICABLE PUBLICATIONS

C. International Building Code (IBC)

D. American Society of Mechanical Engineers (ASME):
A17.1-07......Safety Code for Elevators and Escalators
A17.2-07......Inspectors Manual for Electric Elevators and Escalators

E. National Fire Protection Association:
NFPA 13-10..........Standard for the Installation of Sprinkler Systems
NFPA 70-11..........National Electrical Code (NEC)
NFPA 72-10..........National Fire Alarm and Signaling Code
NFPA 101-09.........Life Safety Code
NFPA 252-08.........Fire Test of Door Assemblies

F. American Society for Testing and Materials (ASTM):
A1008/A1008M-10..........................Steel, Sheet, Cold Rolled, Carbon, Structural, High-Strength Low-Alloy and High Strength Low-Alloy with Improved Farability
E1042-02(R2008) ....Acoustically Absorptive Materials Applied by Trowel or Spray

H. Gauges:
For Sheet and Plate: U.S. Standard (USS)
For Wire: American Wire Gauge (AWG)

I. American Welding Society (AWS):
D1.1-10...Structured Welding Code Steel

J. National Electrical Manufacturers Association (NEMA):

LD-3-05..High-Pressure Decorative Laminates

K. Underwriter's Laboratories (UL):

486A-03..Safety Wire Connectors for Copper Conductors

797-07..Safety Electrical Metallic Tubing

L. Institute of Electrical and Electronic Engineers (IEEE)

1.5 SUBMITTALS

A. Submit in accordance with Specification Section 01 33 23, SHOP DRAWINGS, PRODUCT DATA, and SAMPLES.

B. Before execution of work, furnish information to evidence full compliance with contract requirements for proposed items. Such information shall include, as required: Manufacturer's Name, Trade Names, Model or Catalog Number, Nameplate Data (size, capacity, and rating) and corresponding specification reference (Federal or project specification number and paragraph). All submitted drawings and related elevator material shall be forwarded to the Contracting Officer.

C. Shop Drawings:

1. Complete scaled and dimensioned layout in plan and section view showing the arrangement of equipment and all details of each and every elevator unit specified including:
   a. Hoisting machines, controllers, power conversion devices, governors, and all other components located in machine room.
   b. Car, counterweight, sheaves, supporting beams, guide rails, brackets, buffers, size of car platform, car frame members, and other components located in hoistway.
   c. Rail bracket spacing and maximum vertical forces on guide rails in accordance with ASME A17.1 Section 2.23 and Section 8.4.8 for Seismic Risk Zone 2 or greater.
   d. Reactions at points of supports and buffer impact loads.
   e. Weights of principal parts.
   f. Top and bottom clearances and over travel of car and counterweight.
   g. Location of shunt trip circuit breaker, switchboard panel, light switch, and feeder extension points in the machine room.
2. Drawings of hoistway entrances and doors showing details of construction and method of fastening to the structural members of the building.
   a. If drywall construction is used to enclose hoistway, submit details of interface fastenings between entrance frames and drywall.
   b. Sill details including sill support.

D. Samples:

1. One each of stainless steel, 75 mm x 125 mm (3 in. x 5 in.).
2. One each of baked enamel, 75 mm x 125 mm (3 in. x 5 in.).
3. One each of color vinyl floor tile.
4. One each of protection pads, 75 mm x 125 mm (3 in. x 5 in.) if used.
5. One each car and hoistway Braille plate sample.
6. One each car and hall button sample.
7. One each car and hall lantern/position indicator sample.
8. One each wall and ceiling material finish sample.

9. One each car lighting sample.
10. No other samples of materials specified shall be submitted unless specifically requested after submission of manufacturer's name. If additional samples are furnished pursuant to request, adjustment in contract price and time will be made as provided in Section 00 72 00, GENERAL CONDITIONS.

E. Name of manufacturer, type or style designation, and applicable data of the following equipment shall be shown on the elevator layouts:
   1. Hoisting Machine.
   2. Hoisting Machine Motor, HP and RPM ratings, Voltage, Starting and Full Load Ampere, and Number of Phases.
   3. Controller
   4. Starters and Overload Current Protection Devices.
   5. Car Safety Device; maximum and minimum rated loads and rated speeds.
   6. Governor
   7. Electric Door Operator; HP and RPM ratings, Voltage and Ampere rating of motor.
   8. Hoistway Door Interlocks.
   9. Car and Counterweight Buffers; maximum and minimum rated loads, maximum rated striking speed and stroke.
   10. Hoist and Compensation Ropes; ultimate breaking strength, allowable working load, and actual working load.
   11. Cab Ventilation Unit; HP rating and CFM rating.

F. Complete construction drawings of elevator car enclosure, showing dimensioned details of construction, fastenings to platform, car lighting, ventilation, ceiling framing, top exits, and location of car equipment.

G. Complete dimensioned detail of vibration isolating foundations for traction hoisting machines.

H. Dimensioned drawings showing details of:
   1. All signal and operating fixtures.
   2. Car and counterweight roller guides.
   3. Hoistway door tracks, hangers, and sills.
   4. Door operator, infrared curtain units.

I. Drawings showing details of controllers and supervisory panels.

J. Furnish certificates as required under: Paragraph "QUALIFICATIONS".

1.6 WIRING DIAGRAMS

A. Provide three complete sets of field wiring and straight line wiring diagrams showing all electrical circuits in the hoistway, machine room and fixtures. Install one set coated with an approved plastic sealer and mounted in the elevator machine room as directed by the Resident Engineer.

B. In the event field modifications are necessary during installation, diagrams shall be revised to include all corrections made prior to and during the final inspection. Corrected diagrams shall be delivered to the Resident Engineer within thirty (30) days of final acceptance.

C. Provide the following information relating to the specific type of microprocessor controls installed:
   1. Owner's information manual, containing job specific data on major components, maintenance, and adjustment.
   2. System logic description.

3. Complete wiring diagrams needed for field troubleshooting, adjustment, repair and replacement of components. Diagrams shall be base diagrams, containing all changes and additions made to the equipment during the design and construction period.
4. Changes made during the warranty period shall be noted on the drawings in adequate time to have the finalized drawings reproduced for mounting in the machine room no later than six months prior to the expiration of the warranty period.

1.7 ADDITIONAL EQUIPMENT

A. Additional equipment required to operate the specified equipment manufactured and supplied for this installation shall be furnished and installed by the contractor. The cost of the equipment shall be included in the base bid.

B. Equipment not required by specification, which would improve the operation, may be installed in conjunction with the specified equipment by the contractor at his option at no additional cost to the Government, provided prior approval is obtained from the Contracting Officer’s Technical Representative.

1.8 TOOL CABINET

A. Provide a metal parts/tool cabinet, having two shelves and hinged doors. Cabinet size shall be 1220 mm (48 in.) high, 762 mm (30 in.) wide, and 457 mm (18 in.) deep.

1.9 PERFORMANCE STANDARDS

A. The elevators shall be capable of meeting the highest standards of the industry and specifically the following:
   1. Contract speed is high speed in either direction of travel with rated capacity load in the elevator. Speed variation under all load conditions, regardless of direction of travel, shall not vary more than three (3) percent.
   2. The controlled rate of change of acceleration and retardation of the car shall not exceed 0.1G per second and the maximum acceleration and retardation shall not exceed 0.2G per second.
   3. Starting, stopping, and leveling shall be smooth and comfortable without appreciable steps of acceleration and deceleration.

B. The door operator shall open the car door and hoistway door simultaneously at 2.5-feet per second and close at 1-foot per second.

C. Elevator control system shall be capable of starting the car without noticeable "roll-back" of hoisting machine sheave, regardless of load condition in car, location of car, or direction of travel.

D. Floor level stopping accuracy shall be within 3 mm (1/8 in.) above or below the floor, regardless of load condition.

E. Noise and Vibration Isolation: All elevator equipment including their supports and fastenings to the building, shall be mechanically and electrically isolated from the building structure to minimize objectionable noise and vibration transmission to car, building structure, or adjacent occupied areas of building.

F. Sound Isolation: Noise level relating to elevator equipment operation in machine room shall not exceed 80 dBA. All dBA readings shall be taken three (3) feet off the floor and three (3) feet from equipment.

G. Airborne Noise: Measured noise level of elevator equipment during operation shall not exceed 50 dBA in elevator lobbies and 60 dBA inside car under any condition including door operation and car ventilation exhaust blower on its highest speed.

1.10 WARRANTY

A. Submit all labor and materials furnished in connection with elevator system and installation to terms of "Warranty of Construction" articles of FAR clause 52.246-21. The one year Warranty shall commence after final inspection, completion of performance test, and upon full acceptance of the installation and shall concur with the guarantee period of service.

B. During warranty period if a device is not functioning properly or in accordance with specification requirements, or if in the opinion of the Contracting Officer's Technical Representative, excessive maintenance and attention must be employed to keep device operational, device shall be removed and a new device meeting all requirements shall be installed as part of work until satisfactory operation of installation is obtained. Period of warranty shall start anew for such parts from date of completion of each new installation performed, in accordance with foregoing requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Where stainless steel is specified, it shall be corrosion resisting steel complying with Federal Specification QQ-S-766, Class 302 or 304, Condition A with Number 4 finish on exposed surfaces. Stainless steel shall have the grain of belting in the direction of the longest dimension and surfaces shall be smooth and without waves. During installation all stainless steel surfaces shall be protected with suitable material.

B. Where cold rolled steel is specified, it shall be low-carbon steel rolled to stretcher leveled standard flatness, complying with ASTM A109.

2.2 MANUFACTURED PRODUCTS

A. Materials, devices, and equipment furnished shall be of current production by manufacturers regularly engaged in the manufacture of such items. Items not meeting this requirement, but meet technical specifications which can be established through reliable test reports or physical examination of representative samples, will be considered.

B. When two or more devices of the same class of materials or equipment are required, these units shall be products of one manufacturer.

C. Manufacturers of equipment assemblies which include components made by others shall assume complete responsibility for the final assembled unit.
   1. Individual components of assembled units shall be products of the same manufacturers.
   2. Parts which are alike shall be the product of a single manufacturer.
   3. Components shall be compatible with each other and with the total assembly for the intended service.

D. Motor nameplates shall state manufacturers' name, rated horsepower, speed, volts, starting and full load amperes, and other characteristics required by NEMA Standards and shall be securely attached to the item of equipment in a conspicuous location.

E. The elevator equipment, including controllers, door operators, and supervisory system shall be the product of manufacturers of established reputation, provided such items are capably engineered and produced under coordinated specifications to ensure compatibility with the total operating system. Mixing of manufactures related to a single system or group of components shall be identified in the submittals.

F. Where key operated switches are furnished in conjunction with any component of this elevator installation, furnish four (4) keys for each individual switch or lock. Provide different key tumblers for different switch and lock functions. Each and every key shall have a tag bearing a stamped or etched legend identifying its purpose. Barrel key switches are not acceptable, except where required by code.

G. If the elevator equipment to be installed is not known to the Resident Engineer, the Contractor shall submit drawings in triplicate for approval to the Resident Engineer, Contracting Officer, and VA CFM Elevator Engineer showing all details and demonstrate that the equipment to be installed is in strict accordance with the specifications.

2.4 POWER SUPPLY

A. For power supply in each machine room, see Specification 26 05 21, Electrical specifications, and Electrical drawings.

B. It shall be the Electrical contractor’s responsibility to supply the labor and materials for the installation of the following:

   l. Feeders from the power source indicated on the drawings to each elevator controller.

   2. Shunt Trip Circuit Breaker for each controller shall be located inside machine room at the strike side of the machine room door and lockable in the “Off” position.

   3. Provide Surge Suppressors to protect the elevator equipment.

C. Power for auxiliary operation of elevator as specified shall be available from auxiliary power generator, including wiring connection to the elevator control system.

2.5 CONDUIT AND WIREWAY

A. Unless otherwise specified or approved, install electrical conductors, except traveling cable connections to the car, in rigid zinc-coated steel or aluminum conduit, electrical metallic tubing or metal wireways. Rigid conduit smaller than 3/4 inch or electrical metallic tubing smaller than 1/2 inch electrical trade size shall not be used. All raceways completely embedded in concrete slabs, walls, or floor fill shall be rigid steel conduit. Wireway (duct) shall be installed in the hoistway and to the controller and between similar apparatus in the elevator machine room. Fully protect self-supporting connections, where approved, from abrasion or other mechanical injury. Flexible metal conduit not less than 3/8 inch electrical trade size may be used, not exceeding 18 inches in length unsupported, for short connections between risers and limit switches, interlocks, and for other applications permitted by NEC.

B. All conduits terminating in steel cabinets, junction boxes, wireways, switch boxes, outlet boxes and similar locations shall have approved insulation bushings. Install a steel lock nut under the bushings if they are constructed completely of insulating materials. Protect the conductors at ends of conduits not terminating in steel cabinets or boxes by terminal fittings having an insulated opening for the conductors.

C. Rigid conduit and EMT fittings using set screws or indentations as a means of attachment shall not be used. All fittings shall be steel or malleable iron.

D. Connect motor or other items subject to movement, vibration or removal to the conduit or EMT systems with flexible, steel conduits.

2.6 CONDUCTORS

A. Unless otherwise specified, conductors, excluding the traveling cables, shall be stranded or solid coated annealed copper in accordance with Federal Specification J-C-30B for Type RHW or THW. Where 16 and 18 AWG are permitted by NEC, single conductors or multiple conductor cables in accordance with Federal

Specification J-C-580 for Type TF may be used provided the insulation of single conductor cable and outer jacket of multiple conductor cable is flame retardant and moisture resistant. Multiple conductor cable shall have color or number coding for each conductor. Conductors for control boards shall be in accordance with NEC. Joints or splices are not permitted in wiring except at outlets. Tap connectors may be used in wireways provided they meet all UL requirements.

B. Provide all conduit and wiring between machine room, hoistway and fixtures.

C. All wiring must test free from short circuits or ground faults. Insulation resistance between individual external conductors and between conductors and ground shall be a minimum of one megohm.

D. Where size of conductor is not given, voltage and amperes shall not exceed limits set by NEC.

E. Provide equipment grounding. Ground the conduits, supports, controller enclosure, motor, platform and car frame, and all other non-current conducting metal enclosures for electrical equipment in accordance with NEC. The ground wires shall be copper, green insulated and sized as required by NEC. Bond the grounding wires to all junction boxes, cabinets, and wire raceways.

F. Terminal connections for all conductors used for external wiring between various items of elevator equipment shall be solderless pressure wire connectors in accordance with Federal Specification W-S-610. The Elevator Contractor may, at his option, make these terminal connections on 10 gauge or smaller conductors with approved terminal eyelets set on the conductor with a special setting tool, or with an approved pressure type terminal block. Terminal blocks using pierce-through serrated washers are not acceptable.

2.7 TRAVELING CABLES

A. All conductors to the car shall consist of flexible traveling cables conforming to the requirements of NEC. Traveling cables shall run from the junction box on the car directly to the controller. Junction boxes on the car shall be equipped with terminal blocks. Terminal blocks having pressure wire connectors of the clamp type that meet UL 486A requirements for stranded wire may be used in lieu of terminal eyelet connections. Terminal blocks shall have permanent indelible identifying numbers for each connection. Cables shall be securely anchored to avoid strain on individual terminal connections. Flame and moisture resistant outer covering must remain intact between junction boxes. Abrupt bending, twisting and distortion of the cables shall not be permitted.

B. Provide spare conductors equal to 10 percent of the total number of conductors furnished, but not less than 5 spare conductors in each traveling cable.

C. Provide shielded wires for the auto dial telephone system within the traveling cable. Add 5 pair shielded wires for card reader, 2 RG-6/U coaxial CCTV cables, and 2 pair 14 gauge wires for CCTV power as needed.

D. If traveling cables come into contact with the hoistway or elevator due to sway or change in position, provide shields or pads to the elevator and hoistway to prevent damage to the traveling cables.

E. Hardware cloth wide may be installed from the hoistway suspension point downward to the elevator pit to prevent traveling cables from rubbing or chafing. Hardware cloth shall be securely fastened and tensioned to prevent buckling. Hardware cloth is not required when traveling cable is hung against a flat wall.

2.8 CONTROLLER AND SUPERVISORY PANEL

A. UL/CSA Labeled Controller: Mount all assemblies, power supplies, chassis switches, and relays on a self-supporting steel frame. Completely enclose the equipment and provide a mean to control the temperature. Solid state components shall be designed to operate between 32 to 104 degrees Fahrenheit, humidity non-condensing up to 85 percent.

B. All controller switches and relays shall have contacts of design and material to ensure maximum conductivity, long life and reliable operation without overheating or excessive wear, and shall provide a wiping action to prevent sticking due to fusion. Switches carrying highly inductive currents shall be provided with arc shields or suppressors.

C. Where time delay relays are used in the circuits, they shall be of acceptable design, adjustable, reliable, and consistent such as condenser timing or electronic timing circuits.

D. Properly identify each device on all panels by name, letter, or standard symbol which shall be neatly stencil painted or decaled in an indelible and legible manner. Identification markings shall be coordinated with identical markings used on wiring diagrams. The ampere rating shall be marked adjacent to all fuse holders. All spare conductors to controller and supervisory panel shall be neatly formed, laced, and identified.

2.9 MICROPROCESSOR CONTROL SYSTEM

A. Provide a microprocessor based system with absolute position/speed feedback encoded tape to control the hoisting machine and signal functions in accordance with these specifications. Complete details of the components and printed circuit boards, together with a complete operational description, shall be submitted for approval.

1. All controllers shall be non-proprietary.
2. Proprietary tools shall not be necessary for adjusting, maintenance, repair, and testing of equipment.
3. Controller manufacturer shall provide factory training, engineering and technical support, including all manuals and wiring diagrams to the VA Medical Center's designated Elevator Maintenance Service Provider.
4. Replacement parts shall be shipped overnight within 48 hours of an order being received.

B. All controller assemblies shall provide smooth, step-less acceleration and deceleration of the elevator, automatically and irrespective of the load in the car. All control equipment shall be enclosed in metal cabinets with lockable, hinged door(s) and shall be provided with a means of ventilation. All non-conducting metal parts in the machine room shall be grounded in accordance with NEC. Cabinet shall be securely attached to the building structure.

C. Circuit boards for the control of each and every elevator system; dispatching, signals, door operation and special operation shall be installed in a NEMA Type 1 General Purpose Enclosure. Circuit boards shall be moisture resistant, non-corrosive, non-conductive, fabricated of non-combustible material and adequate thickness to support the components mounted thereon. Mounting racks shall be spaced to prevent accidental contact between individual circuit boards and modules.

D. Modules shall be the type that plug into pre-wired mounting racks. Field wiring or alteration shall not be necessary in order to replace defective modules.

E. Each device, module and fuse (with voltage and ampere rating) shall be identified by name, letter or standard symbol in an approved indelible and legible manner on the device or panel. Coordinate identification markings with identical markings on wiring diagrams.

F. The electrical connections between the printed circuit boards (modules) and the circuit connectors incorporated in the mounting racks shall be made through individual tabs which shall be an integral part of each module. The tabs shall be nickel-gold plated or other approved metal of equal electrical characteristics. Modules shall be keyed or notched to prevent insertion of the modules in the inverted position.

G. Light emitting diodes (LED) shall be for visual monitoring of individual modules.

H. Components shall have interlocking circuits to assure fail-safe operation and to prevent elevator movement should a component malfunction.

I. Method of wire wrapping from point to point with connections on the mounting racks shall be submitted for approval.

J. Field wiring changes required during construction shall be made only to the mounting rack connection points and not to the individual module circuitry or components. If it is necessary to alter individual modules they shall be returned to the factory where design changes shall be made and module design records changed so correct replacement units will be available.

K. All logic symbols and circuitry designations shall be in accordance with ASME and NEC Standards.

L. Solid state components shall be designed to operate within a temperature range of 32 to 104 degrees Fahrenheit, humidity non-condensing up to 85 percent.

M. Wiring connections for operating circuits and for external control circuits shall be brought to terminal blocks mounted in an accessible location within the controller cabinet. Terminal blocks using pierce through serrated washers shall not be used.

2.10 VVVF AC MOTOR CONTROL WITH REGENERATIVE DRIVE

A. Variable Voltage Variable Frequency Motor Control:

1. Elevator control shall be affected by means of a compact solid state motor control unit for each and every elevator with electrical characteristics to suit the power supply. The system shall consist of the necessary three phase, full-wave bridge rectifiers and be equipped with regenerative drive.

2. Solid state motor control unit shall operate with high efficiency and low power consumption, have the capacity to handle peak currents typical of elevator service and contain a balanced, coordinated fault protection system which shall accomplish the following:

    a. Protect the complete power circuit and specifically the power semi-conductors from failure under short circuit (bolted fault) conditions.

    b. Protect against limited faults arising from partial grounds, partial shorts in the motor armature or in the power unit itself.

    c. Protect the drive motor against sustained overloads. A solid state overload circuit shall be used.

    d. Protect motor and power unit against instantaneous peak overload.

    e. Provide semi-conductor transient protection.

    f. Provide phase sequence protection to ensure incoming line is phased properly.

    g. Removable printed circuit boards shall be provided for the VVVF control. Design tabs so boards cannot be reversed.

2.11A AUXILIARY POWER OPERATION

A. The control system for Elevators shall provide for the operation of at least one car per elevator bank on auxiliary power upon failure of the normal power supply.

B. Auxiliary power supply, its starting means, transfer switch for transfer of elevator supply from normal to auxiliary power, two pair of conductors in a conduit from an auxiliary contact on the transfer switch (open or close contacts as required by Controller Manufacturer) to terminals in the group elevator controller and other related work shall be provided by the Electrical Contractor.

C. Auxiliary equipment on elevator controllers, wiring between associated elevator controllers and wiring between elevator controllers and remote selector panel as required to permit the elevators to operate as detailed, shall be provided by the Elevator Contractor.

D. Upon loss of normal power supply there shall be a delay before transferring to auxiliary power of 10 seconds minimum to 45 seconds maximum, the delay shall be accomplished through an adjustable timing device. Following this adjustable delay the associated elevators shall function as follows:

1. Selector switch, Automatic position:
    a. Not more than // one elevator // two elevators // at a time in each group shall be automatically selected and returned to the main floor, at normal speed, cycle its car and hoistway doors and shut down, with "Door Open" button remaining operable.
    b. As each elevator reaches the designated floor and shuts down, another elevator shall start and return to the designated floor.
    c. Elevators that have been manually removed from automatic service and are on independent service, fire service or medical emergency shall receive an automatic return signal. Elevators on inspection service or out of service shall not receive a signal.
    d. When an elevator is given a signal to return and it is unable to start its movement to the designated floor within 30 seconds it shall be by-passed. When an elevator is by-passed, another elevator shall start and return.
    e. This process shall continue until all elevators have returned to the designated floor and shut down.
    f. Any elevator or elevators by-passed on initial return signal shall be signaled again.

2.12A SINGLE CAR SELECTIVE COLLECTIVE AUTOMATIC OPERATION

A. Provide single car selective collective automatic operation.

B. Operate car without attendant from push buttons inside the car and located at each floor adjacent to the elevator entrance. When car is available, automatically start car and dispatch it to the floor corresponding to registered car or hall call. Once car starts it shall respond to registered calls in the direction of travel in the order floors are reached. Do not reverse car directions until all car calls have been answered or until all hall calls ahead of car and corresponding to direction of car travel have been answered. Slow car and stop automatically at floors corresponding to registered calls, in the order in which they are approached in either direction of travel. As slowdown is initiated, automatically cancel the hall call and car call. Hold car at arrival floor an adjustable time interval to allow passenger transfer. Illuminate appropriate push button to indicate call registration. Extinguish light when call is answered.

C. When all calls in the system have been satisfied, the elevator shall shut down at the last landing served with the car and hoistway doors closed. Registration of a call at the landing where the car is parked shall automatically open the car and hoistway doors. Provide a predetermined time delay to permit passengers entering the parked car to register the call of their choice and establish direction of travel before the system can respond to landing calls registered to the same time above or below the parked car.

D. Auxiliary Landing Call Operation: In the event of corridor call button circuit failure, elevators are to service each floor in both directions in a predetermined pattern without registration of a call within the elevator. Provide an illuminated signal in the controller to indicate that emergency dispatch operation is in effect. Restoration of the landing call button system shall cause normal operation to resume.

E. Car lights and fan in the elevator shall not shut off when elevator is idle. Arrange circuits so that power to the lights and outlets on top and bottom of car shall not be interrupted.

2.13 LOAD WEIGHING

A. Provide means for weighing car load for each and every elevator. When load in a car reaches an adjustable predetermined level of the rated capacity, that car shall bypass registered landing calls until the load in the car drops below the predetermined level. Calls bypassed in this manner shall remain registered for the next car. The initial adjustment of the load weighting bypass setting shall be 60 to 100 percent.

2.14 ANTI-NUISANCE FEATURE

A. If weight in the car is not commensurate with the number of registered car calls, cancel car calls. Systems that employ either load weighing or door protective device for activation of this feature are acceptable.

2.15 FIREFIGHTERS' SERVICE

A. Provide Firefighters' Service as per ASME A17.1 Section 2.27.

B. Smoke Detectors:

1. Smoke detection devices that are designated for actuation of Elevator Phase I "FIRE SERVICE" response in each elevator lobby, top of hoistway, and machine room shall be provided by others.
    a. Elevator lobby smoke detectors shall activate only the elevators sharing the corresponding or common lobby.
    b. Top of hoistway smoke detectors shall activate fire recall and the top of hoistway motorized vent.
    c. Elevator or group of elevators serving separate isolated areas of the same floor shall have an independent smoke detection system.
    d. Machine room smoke detectors shall activate fire recall for each and every elevator with equipment located in that machine room.
    e. Hoistway ventilation, provided by others, located at the top of hoistway for elevators that penetrate more than three floors and meets the requirements of ASME A17.1 Section 2.1.4 and IBC Section 3004. The vent shall stay closed under power. When the top of hoistway smoke detector is activated, the power is removed from the vent and the vent shall open. When the smoke detector is reset, the vent shall close by power.

2.18 ELEVATOR MACHINE BEAMS

A. Overhead beams shall meet the requirements of ASME A17.1 Section 2.9 to support machines and machinery in place to prevent any part from becoming loose or displaced under the conditions imposed in service. Machine beams shall be designed as follows:

1. The load resting on the beams and supports shall include the complete weight of the machine, sheaves, controller, governor, and any other equipment, together with the portion of the machine room floor supported by the beams.
2. Two times the sum of the tensions in all wire ropes supported by the beams with rated load in the car.

2.19 GEARLESS AND GEARED TRACTION MACHINE

A. Gearless Traction Hoist Machine:

1. Gearless traction machine with an AC motor, brake, drive sheave, and deflector sheave mounted in proper alignment on an isolated bedplate.
2. Provide hoist machine mounted direct drive, digital, closed-loop velocity encoder.
3. Armature must be electrically balanced and together with motor coupling and brake, mechanically balanced.
4. The structural design of the motor shall ensure perfect alignment of bearings. The rotating elements shall be dynamically balanced to minimize vibration.
5. Hoist machine shaft shall be supported by two bearings mounted on a bedplate or integral with machine frame. Shaft shall be of forged steel or close grain electric furnace cast steel.
6. Drive sheaves shall be free from cracks, sand holes, and other imperfections that would tend to injure the hoist ropes. Sheave shall be turned smooth and true with rope grooves of proper design to ensure maximum traction and maximum life of the hoist ropes. Traction sheave shall be mechanically coupled to the hoist motor shaft centered in a positive manner.
7. Hoisting machine brake shall be drum or disc type and shall have the capacity to hold the elevator with 125 percent of rated load. Arrange brake circuits so that no current shall be applied to the brake coil prior to the establishment of the hoistway door interlock circuit, except during leveling, re-leveling, and hoistway access operation.

2.20 SHEAVES

A. Provide deflector sheaves with a metal basket type guard mounted below the sheave and a guard to prevent ropes from jumping out of grooves. Securely fasten guard to sheave beams.

B. Two-to-one idler sheaves on car and counterweight, if used, shall be provided with metal guards that shall prevent foreign objects from falling between ropes and sheave grooves and accidental contact or injury to workers on top of the car. Fabricate sheave guards from not less than 10-gauge thick steel and install with minimum clearance between guard and cables to prevent ropes from jumping out of grooves.

2.21 HOIST ROPES

A. Provide elevator with the required number and size of ropes to ensure adequate traction for the range of loads with a factor of safety not less than that required by ASME A17.1 Section 2.20. Hoisting ropes shall be preformed 8 x 19 or 8 x 25 traction steel, conforming to Federal Specification RR-W-410 with minimum nominal diameter of 0.50 inch. For machines located overhead, 6 x 19 preformed traction steel hoisting ropes may be used in lieu of 8 x 19 that meet the requirements of the sheave manufacturer, at the elevator contractor’s option.

B. Securely attach a corrosion resistant metal data tag to one hoisting rope fastening on top of the elevator.

C. Provide wedge type shackles.

2.22 HOIST ROPE COMPENSATION

A. Provide compensation when required by controller manufacturer for elevators with travel of 15.15 m (50ft) or more. Compensation shall consist of a necessary number and size of encapsulated chains or whisper flex attached to the underside of car and counterweight frames. Hoist rope compensation shall meet the requirements of ASME A17.1 Rule 2.21.4.

1. Provide pit guide to minimize chain sway.
2. Provide take-up to compensate for hoist rope stretch.
3. Pad areas where compensation may strike car or hoistway items.

B. Compensation shall consist of a necessary number and size of iron or steel wire ropes attached to the underside of car and counterweight frames, passing under a weighted idler sheave in pit. A metal tag giving the number, diameter, type, month and year installed, and the name of manufacturer of compensating ropes shall be securely attached to one of the compensating rope fastenings.

1. Provide means for equalizing tension in the compensating ropes.
2. Provide idler sheave with ball or roller bearings. Mount sheave on steel guide rails.
3. Provide a metal guard over compensating sheave.
4. Provide a sheave contact in accordance with ASME A17.1 Rule 2.26.2.3.
5. Provide take-up to compensate for future cable stretch.

2.23 GOVERNOR ROPE

A. Governor Rope shall be 6 x 19 or 8 x 19 wire rope, preformed traction steel, uncoated, fiber core, conforming to Federal Specification RR-W-410 with minimum nominal diameter of 0.375 inch having a minimum safety factor of 5. Tiller rope construction is not acceptable.

B. Under normal operation rope shall run free and clear of governor jaws, rope guards, and other stationary parts.

C. Securely attach governor rope tag to governor rope releasing carrier. Data tag shall be corrosion-resisting metal and bear data as required by ASME A17.1 Section 2.18.

2.24 SPEED GOVERNOR

A. Provide Centrifugal type car driven governor, in accordance with ASME A17.1 Section 2.18, to operate the car safety device // and counterweight governor to operate the counterweight safety device //. Governor shall be complete with weighted pit tension sheave, governor release carrier and mounting base with protected cable sleeves.

B. Furnish overspeed switch and speed reducing switches when required.

C. The governor rope clamping device shall be designed so that no appreciable damage to or deformation of the governor rope shall result from the stopping action of the device in operating the safety.

D. Provide anti-friction metal bearings for the governor and pit tension sheaves. Bearing shall be either self-oiling or Zerk fitting type connections. Ball or roller bearings may be used in lieu of sleeve type.

E. Provide metal guard over top of governor rope and sheaves.

F. Governor, with the exception of finished surfaces, screw threads, etc., shall be factory painted and shall operate freely. Field painting of governor parts shall be permitted in accordance with ASME A17.1 Rule 2.18.3.1.

G. Where the elevator travel does not exceed 100 feet, the weight tension sheave may be mounted on a pivoted steel arm in lieu of operating in steel guides.

2.25 CAR SAFETY DEVICE

A. Provide "Type B Safeties" on the elevator that meets the requirements of ASME A17.1 Section 2.17.

B. Field testing of car safety and governor shall be as specified in Section 3.7 PRETEST and TEST of this specification.

2.26 ASCENDING CAR OVERSPEED PROTECTION

A. Provide a device to prevent ascending over speed and unintended motion away from the landing when the doors are not locked in accordance with ASME A17.1 Section 2.19.

2.27 CAR AND COUNTERWEIGHT BUFFERS

A. Provide a minimum of two buffers for each car and one for each counterweight that meet the requirements of ASME A17.1 Section 2.22. Securely fasten buffers and supports to the pit channels and in the alignment with striker plates on car and counterweight. Each installed buffer shall have a permanently attached metal plate indicating its stroke and load rating. Buffer anchorage shall not puncture pit waterproofing.

B. Design and install buffers to provide minimum car runby required by ASME A17.1 Rule 2.4.2.

C. Furnish pipe stanchions and struts as required to properly support the buffer.

2.28 COUNTERWEIGHTS

A. Elevator shall be counterweighted with the weight of the car plus 40-50 percent of the rated capacity load as required by the controller manufacturer.

B. Furnish two (2) tie rods with cotter pins and double nuts at top and bottom. Install counterweight retainer plates or other approved means on tie rods to prevent counterweight sub-weights from jumping and/or rattling. Both ends of tie-rods shall be visible and accessible.

C. Provide counterweight guards in the pit in accordance with ASME A17.1 Section 2.3.

2.29 CAR AND COUNTERWEIGHT ROLLER/SLIDE GUIDES

A. Provide car and counterweight with adjustable roller guides.

B. Each guide shall be of an approved type consisting of not less than three (3) wheels, each with a durable, resilient oil-resistant material tire rotating on ball bearings having sealed-in lubrication. Assemble rollers on a substantial metal base and mount to provide continuous spring pressure contact of all wheels with the corresponding rail surfaces under all conditions of loading and operation. Secure the roller guides at top and bottom on each side of car frame and counterweight frame. All mounting bolts shall be fitted with nuts, flat washers, split lock washers, and if required, beveled washers.

C. Provide sheet metal guards to protect wheels on top of car and counterweight.

D. Minimum diameter of car rollers shall be 150 mm (6 in.) unless the six wheel roller type is used. The entire elevator car shall be properly balanced to equalize pressure on all guide rollers. Cars shall be balanced in post-wise and front-to-back directions. Test for this balanced condition shall be witnessed at time of final inspection.

E. Minimum diameter of counterweight rollers shall not be less than // 100 mm (4 in.) // 75 mm (3 in.) //. Properly balance counterweight frame to equalize pressure on all guide rollers. The Contractor shall have the option of furnishing, for counterweight only, mechanically adjusted roller guide in lieu of spring loaded roller guides as specified.

F. Equip all cars and counterweight with an auxiliary guiding device for each guide shoe which shall prevent the car or counterweight from leaving the rails in the event that the normal guides are fractured. These auxiliary guides shall not, during normal operation, touch the guiding surfaces of the rails. Fabricate the auxiliary guides from hot rolled steel plate and mount between the normal guide shoes and the car and counterweight frames. The auxiliary guides may be an extension of the normal guide shoe mounting plate if that plate is fabricated from hot rolled steel. The portion of the auxiliary guide which shall come in contact with the rail guiding surfaces in the event of loss of the normal guides shall be lined with an approved bearing material to minimize damage to the rail guiding surfaces.

G. Alternate guide shoes for Freight Elevator: Install on car frame four flexible sliding swivel guide shoes each assembled on a substantial metal base, to permit individual self-alignment to the guide rails.
   1. Provide each shoe with renewable non-metallic gibs of durable material having low coefficient of friction and long-wearing qualities, when operated on guide rails receiving infrequent, light applications of rail lubricant. Gibs containing graphite or other solid lubricants are not acceptable.
   2. Flexible guide shoes of approved design, other than swivel type, may be used provided they are self-aligning on all three faces of the guide rails.
   3. Provide spring take-up in car guide shoes for side play between rails.

2.30 GUIDE RAILS, SUPPORTS AND FASTENINGS

A. Guide rails shall conform to ASME A17.1 Section 2.23.

B. Guide rails for car shall be planed steel T-sections and weigh // 27.5 kg/m. Guide rails for counterweight shall be planed steel T-sections and weigh 12.0 kg/m.

C. Securely fasten guide rails to the brackets or other supports by heavy duty steel rail clips.

D. Provide necessary car and counterweight rail brackets and counterweight spreader brackets of sufficient size and design to secure substantial rigidity to prevent spreading or distortion of rails under any condition.
   1. Slotted or oversized holes shall be fitted with flat washers and shall conform to ASME A17.1 Rule 2.23.10.3.
   2. Where fastenings are over 4.2 m (14 ft) apart, rails shall be reinforced with 228 mm (9 in.) channel or approved equal backing to secure the rigidity required.

E. Rail joints and fishplates shall be in accordance with ASME A17.1 Rule 2.23.7. Rail joints shall not interfere with clamps and brackets. Design rail alignment shims to remain in place if fastenings become loose.

F. Guide rails shall extend from channels on pit floor to within 76 mm (3 in.) of the underside of the concrete slab or grating at top of hoistway with a maximum deviation of 3.2 mm (1/8 in.) from plumb in all directions. Provide a minimum of 19 mm (3/4 in.) clearance between bottom of rails and top of pit channels.

G. Guide rail anchorages in pit shall be made in a manner that will not reduce effectiveness of the pit waterproofing.

H. In the event inserts or bond blocks are required for the attachment of guide rails, the Contractor shall furnish such inserts or bond blocks and shall install them in the forms before the concrete is poured. Use inserts or bond blocks only in concrete or block work where steel framing is not available for support of guide rails. Expansion-type bolting for guide rail brackets will not be permitted.

I. Guide rails shall be clean and free of any signs of rust, grease, or abrasion before final inspection. Paint the shank and base of the T-section with two field coats of manufacturer’s standard enamel.

J. After completion of car safety testing during final inspection, all marks left on rails by application of car safety shall be filed smooth.

2.31 NORMAL AND FINAL TERMINAL STOPPING DEVICES

A. Normal and final terminal stopping devices shall conform to ASME A17.1 Section 2.25.

B. Mount terminal slowdown switches and direction limit switches on the elevator or in hoistway to reduce speed and bring car to an automatic stop at the terminal landings.

1. Switches shall function with any load up to and including 125 percent of rated elevator capacity at any speed obtained in normal operation.
2. Switches, when opened, shall permit operation of elevator in reverse direction of travel.

C. Mount final terminal stopping switches in the hoistway.

1. Switches shall be positively opened should the car travel beyond the terminal direction limit switches.
2. Switches shall be independent of other stopping devices.
3. Switches, when opened, shall remove power from hoist motor, apply hoist machine brake, and prevent operation of car in either direction.

D. After final stopping switches have been adjusted, through bolt switches to guide rail.

2.32 CROSSHEAD DATA PLATE AND CODE DATA PLATE

A. Permanently attach a non-corrosive metal Data Plate to car crosshead. Data plate shall bear information required by ASME A17.1 Section 2.16.3 and 2.20.2.1.

B. Permanently attach a Code Data Plate, in plain view, to the controller, ASME A17.1 Section 8.9.

2.33 WORKMAN'S LIGHTS AND OUTLETS

A. Provide duplex GFCI protected type receptacles and lamps with guards on top of each elevator car and beneath the platform. The receptacles shall be in accordance with Fed. Spec. W-C-596 for Type D7, 2-pole, 3-wire grounded type, rated for 15 amperes and 125 volts.

2.34 TOP-OF-THE CAR OPERATING DEVICE

A. Provide a cartop operating device that meets the requirements of ASME A17.1 Section 2.26.

B. The device shall be activated by a toggle switch mounted in the device. The switch shall be clearly marked "INSPECTION" and "NORMAL" on the faceplate, with 6 mm (1/4 in.) letters.

C. Movement of the elevator shall be accomplished by the continuous pressure on a direction button and a safety button.

D. Provide an emergency stop toggle type switch.

E. Provide permanent identification for the operation of all components in the device.

F. The device shall be permanently attached to the elevator crosshead on the side of the elevator nearest to the hoistway doors used for accessing the top of the car.

2.35 CAR LEVELING DEVICE

A. Car shall be equipped with a two-way leveling device to automatically bring the car to within 3 mm (1/8 in.) of exact level with the landing for which a stop is initiated regardless of load in car or direction.

B. If the car stops short or travels beyond the floor, the leveling device, within its zone shall automatically correct this condition and maintain the car within 3 mm (1/8 in.) of level with the floor landing regardless of the load carried.

C. Provide encoded steel tape, steel tape with magnets or steel vanes with magnetic switches. Submit design for approval.

2.36 EMERGENCY STOP SWITCHES

A. Provide an emergency stop switch for each top-of-car device, pit, machine spaces, service panel and firefighters' control panel inside the elevator. Mount stop switches in the pit adjacent to pit access door, at top of the pit ladder 1220 mm (48 in.) above the bottom landing sill and 1220 mm (48 in.) above the pit floor adjacent to the pit ladder.

B. Each stop switch shall be red in color and shall have "STOP" and "RUN" positions legibly and indelibly identified.

2.37 MAIN CAR OPERATING PANEL

A. Locate the main car operating panel in the car enclosure on the front return panel for passenger/service elevators and the front of the side wall for freight elevators. The top floor car call push button shall not be more than 1220 mm (48 in.) above the finished floor. Car call push buttons and indicator lights shall be round with a minimum diameter of 25 mm (1 in.), LED white light illuminated.

B. One piece front faceplate, with edges beveled 15 degrees, shall have the firefighters' service panel recessed into the upper section and the service operation panel recessed into the lower section, fitted with hinged doors. Doors shall have concealed hinges, be in the same front plane as the faceplate and fitted with cylinder type key operated locks. Secure the faceplate with stainless steel tamperproof screws.

C. All terminology on the main car operating panel shall be raised or engraved. Use 6 mm (1/4 in.) letters to identify all devices in upper section of the main car operating panel. The handicapped markings with contrasting background shall be recessed .030 inch in the faceplate, square or rectangular in shape, with the finished face of the 12 mm (1/2 in.) numerals and markings flush with the faceplates. Surface mounted plates are not acceptable.

D. The upper section shall contain the following items in order listed from top to bottom:

1. Engrave elevator number, 25 mm (1 in.) high with black paint for contrast.
2. Engrave capacity plate information with black paint for contrast with freight loading class and number of passengers allowed.
3. Emergency car lighting system consisting of a rechargeable battery, charger, controls, and LED illuminated light fixture. The system shall automatically provide emergency light in the car upon failure or interruption of the normal car lighting service, and function irrespective of the position of the light control switch in the car. The system shall be capable of maintaining a minimum illumination of 1.0 foot-candle when measured 1220 mm (48 in.)above the car floor and approximately 305 mm (12 in.) in front of the car operating panel, for not less than four (4) hours.
4. LED illuminated digital car position indicator with direction arrows. Digital display floor numbers and direction arrows shall be a minimum of 50mm (2 in.) high.
5. Firefighters' Emergency Operation Panel shall conform to the requirements of ASME A17.1 Section 2.27. Firefighters' Panel shall be 1676 mm (66 in.) minimum to 1830 mm (72 in.) maximum to the top of the panel above finished floor.
6. Firefighters' Emergency Indicator Light shall be round with a minimum diameter of 25 mm (1 in.).
7. Medical Emergency switch marked "MEDICAL EMERGENCY" with two positions labeled "ON" and "OFF" and Medical Emergency Indicator Light located next to the key switch shall be round with a

minimum diameter of 25 mm (1 in.). Instruction for Medical Emergency operation shall be engraved below the key switch and light.

8. Key operated Independent Service; see Section 2.39 for detailed description.
9. Provide a Door Hold button on the faceplate next to the independent service key switch. It shall have “DOOR HOLD” indelibly marked on the button. Button shall light when activated. When activated, the door shall stay open for a maximum of one minute. To override door hold timer, push a car call button or door close button. Door Hold button is not ADA required and Braille is not needed.
10. Complete set of round car call push buttons, minimum diameter of 25 mm (1 in.), and LED white light illuminated, corresponding to the floors served. Car call buttons shall be legibly and indelibly identified by a floor number and/or letter not less than 12mm (1/2 in.) high in the face of the call button. Stack buttons in a single vertical column for low rise buildings up to six floors with front openings only.
11. Door Open and Door Close buttons shall be located below the car call buttons. They shall have “OPEN” and “CLOSE” legibly and indelibly identified by letters in the face of the respective button. The Door Open button shall be located closest to the door jamb as required by ADA.
12. Red Emergency Alarm button that shall be located below the car operating buttons. Mount the emergency alarm button not lower than 890 mm (35 in.) above the finished floor. It shall be connected to audible signaling devices as required by A17.1 Rule 2.27.1.2. Provide audible signaling devices including the necessary wiring.
13. Emergency Help push button shall activate two way communications by Auto Dial telephone system as required by ASME A17.1 Rule 2.27.1.1.3. Help button shall be LED white light illuminated and flash when call is acknowledged. Legibly and indelibly label the button “HELP” in the face of the button with 12 mm (1/2 in.) high letters.
14. Provide a corresponding Braille plate on the left side of each button. The handicapped markings with contrasting background shall be recessed .030 inch in the faceplate, square or rectangular in shape, with the finished face of the 12 mm (1/2 in.) numerals and markings flush with the faceplates. Surface mounted plates are not acceptable.

E. The service operation panel, in the lower section shall contain the following items:

1. Light switch labeled “LIGHTS” for controlling interior car lighting with its two positions marked “ON” and “OFF”.
2. Inspection switch that will disconnect normal operation and activate hoistway access switches at terminal landings. Switch shall be labeled “INSPECTION” with its two positions marked “ON” and “OFF”.
3. Three position switch labeled “FAN” with its positions marked “HIGH”, “LOW” and “OFF” for controlling car ventilating blower.
4. Two position, spring return, toggle switch or push button to test the emergency light and alarm device. It shall be labeled “TEST EMERGENCY LIGHT AND ALARM”.
5. Two position emergency stop switch, when operated, shall interrupt power supply and stop the elevator independently of regular operating devices. Emergency stop switch shall be marked “PULL TO STOP” and “PUSH TO RUN”.

2.39 INDEPENDENT SERVICE

A. Provide a legibly and indelibly labeled "INDEPENDENT SERVICE", two-position key operated switch on the face of the main car operating panel that shall have its positions marked "ON" and "OFF". When the switch is in the "ON" position, the car shall respond only to calls registered on its car dispatch buttons and shall bypass all calls registered on landing push buttons. The car shall start when a car call is registered, car call button or door close button is pressed, car and hoistway doors are closed, and interlock circuits are made. When switch is returned to "OFF" position, normal service shall be resumed.

2.40 CAR POSITION INDICATOR

A. Provide an alpha-numeric digital car position indicator in the main car operating panel, consisting of numerals and arrows not less than 50 mm (2 in.) high, to indicate position of car and direction of car travel. Locate position indicator at the top of the main car operating panel, illuminated by light emitting diodes.

2.41 AUDIO VOICE SYSTEM

A. Provide digitized audio voice system activated by stopping at a floor. Audio voice shall announce floor designations, direction of travel, and special announcements. The voice announcement system shall be a natural sounding human voice that receives messages and shall comply with ADA requirements for audible car position indicators. The voice announcer shall have two separate volume controls, one for the floor designations and direction of travel, and another for special announcements. The voice announcer shall have a full range loud speaker, located on top of the cab. The audio voice unit shall contain the number of ports necessary to accommodate the number of floors, direction messages, and special announcements. Install voice announcer per manufacturer’s recommendations and instructions. The voice system shall be the product of a manufacturer of established reputation. Provide manufacturer literature and list of voice messages.

1. Fire Service Message
2. Medical Emergency Service Message
3. “Please do not block doors”
4. Provide special messages as directed by Resident Engineer.

2.42 AUTO DIAL TELEPHONE SYSTEM

A. Furnish and install a complete ADA compliant intercommunication system.

B. Provide a two-way communication device in the car with automatic dialing, tracking and recall features with shielded wiring to car controller in machine room. Provide dialer with automatic rollover capability with minimum two numbers.

C. “HELP” button shall illuminate and flash when call is acknowledged. Button shall match floor push button design.

D. Provide “HELP” button tactile symbol engraved signage and Braille adjacent to button mounted integral with car operating panels.

E. The auto dial system shall be located in the auxiliary car operating panel. The speaker and unit shall be mounted on the backside of the perforated stainless steel plate cover.

F. Each elevator shall have individual phone numbers.

G. If the operator ends the call, the phone shall be able to redial immediately.

2.43 CORRIDOR OPERATING DEVICE FACEPLATES

A. Fabricate faceplates for elevator operating and signal devices from not less than 3 mm (1/8 in.) thick flat stainless steel with all edges beveled 15 degrees. Install all faceplates flush with surface on which they are mounted.

B. Corridor push button faceplates shall be at least 127 mm (5 in.) wide by 305 mm (12 in.) high. The centerline of the landing push buttons shall be 1067 mm (42 in.) above the corridor floor.

C. Elevator Corridor Call Station Pictograph shall be engraved in the faceplate.

D. Fasten all car and corridor operating device and signal device faceplates with stainless steel tamperproof screws.

E. Design corridor push button faceplates so that pressure on push buttons shall be independent of pressure on push button contacts.

F. Engraved legends in faceplates shall have lettering 6 mm (1/4 in.) high filled with black paint.

G. Provide a corresponding Braille plate on the left side of each button. The handicapped markings with contrasting background shall be recessed .030 inch in the faceplate, square or rectangular in shape, with the finished face of the 12 mm (1/2 in.) numerals and markings flush with the faceplates. Surface mounted plates are not acceptable.

2.44A CORRIDOR OPERATING DEVICES FOR PASSENGER/SERVICE ELEVETORS

A. Provide one risers of landing call buttons located as shown on contract drawings.

B. Fixtures for intermediate landings shall contain "UP" and "DOWN" buttons. Fixtures for terminal landings shall contain a single "UP" or "DOWN" button.

C. Each button shall contain an integral registration LED white light which shall illuminate upon registration of a call and shall extinguish when that call is answered.

D. The direction of each button shall be legibly and indelibly identified by arrows not less than 12 mm (1/2 in.) high in the face of each button.

E. Two or more risers of landing call buttons, if specified, shall be cross-connected so that either "UP" or "DOWN" buttons at a floor shall be capable of registering a call to that floor for the entire elevator group. Registration of a landing call shall illuminate "UP" or "DOWN" buttons simultaneously, and upon satisfaction of that call, both buttons shall be extinguished simultaneously.

F. Landing push buttons shall not re-open the doors while the car and hoistway doors are closing at that floor, the call shall be registered for the next available elevator. Calls registered shall be canceled if closing doors are re-opened by means of "DOOR OPEN" button or infrared curtain unit.

2.45 DIGITAL CORRIDOR LANTERN/POSITION INDICATOR

A. Provide each car with combination corridor lantern/position indicator digital display mounted over the hoistway entrances at each and every floor. Provide each terminal landing with "UP" or "DOWN", minimum 64 mm (2 1/2 in.) high digital arrow lanterns and each intermediate landing with "UP" and "DOWN" digital arrow lanterns. Each lens shall be LED illuminated of proper intensity, so shielded to illuminate individual lens only. The lenses in each lantern shall be illuminated green to indicate "UP" travel and red to indicate "DOWN" travel. Lanterns shall signal in advance of car arrival at the landing indicating the direction of travel whether or not corridor button has been operated at that floor. Hall calls shall receive immediate assignment to individual cars and hall lantern shall sound and illuminate. Corridor lanterns shall not be illuminated when a car passes a floor without stopping. Each lantern shall be equipped with a clearly audible electronic chime which shall sound once for "UPWARD" bound car and twice for "DOWNWARD" bound car. Audible signal shall not sound when a car passes the floor without stopping. Provide adjustable sound level on audible signal. Car riding lanterns are not acceptable.

B. Provide alpha-numeric digital position indicators directly over hoistway landing entranceways between the arrival lanterns at each and every floor. Indicator faceplate shall be stainless steel. Numerals shall be not less than 50 mm (2 in.) high with direction arrows. Cover plates shall be readily removable for re-lamping. The appropriate direction arrow shall be illuminated during entire travel of car in corresponding direction.

C. Provide LED illumination in each compartment to indicate the position and direction the car is traveling by illuminating the proper alpha-numeric symbol. When the car is standing at a landing without direction established, arrows shall not be illuminated.

2.46 HOISTWAY ACCESS SWITCHES

A. Provide hoistway access switches for elevator at top terminal landing to permit access to top of car, and at bottom terminal landing to permit access to pit. // Elevators with side slide doors, mount the access key switch 1830 mm (6 ft) above the corridor floor in the wall next to the strike jamb. // Elevators with center opening doors, mount the access key switch 1830 mm (6 ft) above the corridor floor next to the hoistway entrance jamb.// Exposed portion of each access switch or its faceplate shall have legible, indelible legends to indicate "UP", "DOWN", and "OFF" positions. Submit design and location of access switches for approval. Each access switch shall be a constant pressure cylinder type lock having not less than five pins or five stainless steel disc combination with key removable only when switch is in the "OFF" position. Lock shall not be operable by any other key which will operate any other lock or device used for any other purpose at the VA Medical Center. Arrange the hoistway switch to initiate and maintain movement of the car. When the elevator is operated in the down direction from the top terminal landing, limit the zone of travel to a distance not greater than the top of the car crosshead level with the top floor.

B. Provide emergency access for all hoistway entrances, keyways for passenger and service elevators and locked door release system (key access) for freight elevators.

2.47 HOISTWAY ENTRANCES: PASSENGER/SERVICE ELEVATORS

A. Provide entrances of metal construction using cold rolled steel. Door frames shall be constructed of stainless steel. Complete entrances with sills, hanger supports, hangers, tracks, angle struts, unit frames, door panels, fascia plates, toe guards, hardware, bumpers, sight guards, and wall anchors.

B. Provide one piece extruded // aluminum // nickel silver // stainless steel // sills with non-slip wearing surface, grooved for door guides and recessed for fascia plates. Sills shall have overall height of not less than 19 mm (3/4 in.), set true, straight, and level, with hoistway edges plumb over each other, and top surfaces flush with finished floor. Grout sills full length after installation.

C. Construct hanger supports of not less than 4.5 mm (3/16 in.) thick steel plate, and bolted to strut angles.

D. Structural steel angles // 76 mm x 76 mm x 9 mm (3 in. x 3 in. x 3/8 in.) // 127 mm x 127 mm x 13 mm (5 in. x 5 in. x 1/2 in.) // shall extend from top of sill to bottom of floor beam above, and shall be securely fastened at maximum 457 mm (18 in.) on center and at each end with two bolts.

E. Provide jambs and head soffits, of not less than 14-gauge stainless steel, for entrances. Jambs and head soffits shall be bolted or welded construction, and provided with three anchors each side. Side jambs shall be curved type. Radius of curvature shall be 89 mm (3 1/2 in.). Head jamb shall be square type, and shall overhang corridor face of side jambs by 6 mm (1/4 in.). Rigidly fasten jambs and head soffits to building structure. Provide jambs with protective covering. After installation, protect jambs and head soffits with wood framing to prevent damage to finish during construction. Solidly grout jambs.

F. Provide 14-gauge sheet steel fascia plates in hoistway to extend vertically from head of hanger support housing to sill above. Plates shall be the same width as the door opening of elevator and adequately reinforced to prevent waves and buckles. Below bottom terminal landing and over upper terminal landing provide shear guards beveled back to and fastened to the wall. // Where rear openings are used, provide shear guards and fascia plates as required by ASME A17.1. //

G. Provide hoistway entrance with flush // two speed side slide // center opening // hoistway doors for Elevators P_____ // S_____ //. Door panels shall be not less than 16-gauge stainless steel, flush type construction, and not less than 32 mm (1 1/4 in.) thick. Wrap stainless steel around the leading and trailing edges of the door panel. Top and bottom of door panels shall have continuous stiffener channels welded in place. Reinforcement of the door panels shall be approximately 1.0 mm (0.04 in.) in thickness and of the hat section type. At bottom of each and every panel, provide two removable laminated phenolic gibs or other approved material guides and a separate fire gib. Reinforce each door panel for hangers, interlock mechanism, drive assembly, and closer. One door panel for each entrance shall bear a BOCA label, Underwriters' label, or in lieu of this, labels from other accredited test laboratories may be furnished provided they are based on fire test reports and factory inspection procedures acceptable to the COTR. Fasten sight guard of 14-gauge stainless steel, extending full height of panel, to leading edge of // fast speed panel of two-speed doors // each panel of center opening doors. //

H. Provide hangers for hoistway door panels and provide relating devices to transmit motion from one door panel to the other. Fasten the hangers to the door sections. Provide reinforcements at the point of attachment. The hanger shall have provisions for vertical and lateral adjustments. Hang doors on two-point suspension hangers having sealed ball-bearing sheaves not less than 76 mm (3 in.) in diameter, with rubber or non-metallic sound-reducing tires mounted on a malleable iron
or steel bracket. The hanger sheaves shall operate at a relatively low rotational speed, and shall roll on a high-carbon, cold-rolled or drawn steel track shaped to permit free movement of sheaves without regard to vertical adjustment of sheave, bracket or housing. Beneath the track and each hanger sheave, provide a hardened steel up-thrust roller capable of withstanding a vertical thrust equal to the carrying capacity of adjacent upper sheave. The up-thrust shall have fine vertical adjustments, and the face of the roller shaped so as to permit free movement of the hanger sheave. The up-thrust roller shall have ball or roller bearings. Provide the hanger sheaves with steel fire stops to prevent disengagement from tracks.

I. Do not use hangers that are constructed integrally with the door panels.

J. Provide raised numerals on cast, rear mounted plates for all openings. Numerals shall be a minimum of 50 mm (2 in.) high, located on each side of entrance frame, with centerline of 1524 mm (5 ft) above the landing sill. The number plates shall contain Braille.

K. Provide unique car number on every elevator entrance at designated main fire service floor level, minimum 76 mm (3 in.) in height.

2.48 ELECTRIC INTERLOCKS

A. Equip each hoistway door with an interlock, functioning as hoistway unit system, to prevent operation of car until all hoistway doors are locked in closed position. Hoistway door interlocks shall not be accepted unless they meet the requirements of ASME A17.1 Section 2.12.

B. Equip car doors with electric contact that prevents operation of car until doors are closed unless car is operating in leveling zone or hoistway access switch is used. Locate door contact to prevent its being tampered with from inside of car. Car door contact shall not be accepted unless it meets the requirements of ASME A17.1 Section 2.12.

C. Wiring installed from the hoistway riser to each door interlock shall be NEC type SF-2 or equivalent.

1. Type SF-2 cable terminations in the interlock housing shall be sleeved with glass braid fillers or equivalent.

D. Provide devices, either mechanical or electrical, that shall prevent operation of the elevator in event of damaged or defective door equipment that has permitted an independent car or hoistway door panel to remain in the "unclosed" and "unlocked" position.

2.49 CAR FRAME: PASSENGER/SERVICE ELEVATORS

A. Car frame shall conform to the requirements of ASME A17.1 Section 2.15, constructed of steel plates and structural shapes securely riveted, bolted, or welded together. Iron casting shall not be permitted. The entire assembly shall be rugged construction, and amply braced to withstand unequal loading of platform. Car frame members shall be constructed to relieve the car enclosure of all strains. Balance car front to back and side to side. Provide balancing weights and frames, properly located, to achieve the required true balance.

2.50 CAR PLATFORM: PASSENGER/SERVICE ELEVATORS

A. Construct the car platform to comply with all the requirements of ASME A17.1 Section 2.15.5. The platform shall be designed to withstand the forces developed under the loading conditions specified. Provide car entrances with extruded aluminum sill or better with machined or extruded guide grooves. Cover underside and all exposed edges of wood filled platform with sheet metal of not less than 27-gauge, with all exposed joints and edges folded under. Fire resistant paint is not acceptable. Platform shall have flexible composition flooring not less than 3 mm (1/8 in.) thick.. Adhesive material shall be type recommended by manufacturer of flooring. Lay flooring flush with threshold plate and base.

B. Provide a platform guard (toe guard) that meets the requirements of ASME A17.1 Section 2.15.9, of not less than 12-guage sheet-steel on the entrance side, extend 76 mm (3 in.) beyond each side of entrance jamb. Securely brace platform guard to car platform, and bevel bottom edge at a 60-75 degree angle from horizontal. Install platform in the hoistway, so that the clearance between front edge and landing threshold shall not exceed 32 mm (1 1/4 in.).

C. Isolate the platform from the car frame by approved rubber pads or other equally effective means.

D. Provide adjustable diagonal brace rods to hold platform firmly within car suspension frame.

E. Provide a bonding wire between frame and platform.

2.51 CAR ENCLOSURE: PASSENGER/SERVICE ELEVATORS

A. Car enclosure shall have a dome height inside the cab of 2440 mm (8 ft).

B. Securely fasten car enclosure to platform by through bolts located at intervals of not more than 457 mm (18 in.) running through an angle at the base of panels to underside of platform. Provide 6 mm (1/4 in.) bolts with nuts and lock washers.

C. Car enclosure base shall be of 14-gauge stainless steel, 152 mm (6 in.) high. Provide straight type base at front return sides. Vertical face of base at sides and rear shall be flush with or recessed behind the wainscot directly above the base. There shall be no exposed fastenings in base. Provide natural ventilation openings divided equally between the bottom and top of the car enclosure that shall provide a minimum 3.5 percent of the inside car floor area.

D. Construct canopy of not less than 12-gauge steel.

E. Car top railings that meet the requirement of ASME A17.1 Rules 2.14.1.7 and 2.10.2.

F. Front return wall panel, entrance columns, rear corner columns, entrance head-jamb and transom shall be 14-gauge stainless steel full height of car. Side and rear walls from top of base to top of panel shall be constructed of 14-gauge cold rolled steel. Side and rear walls up to 1220 mm (48 in.) above finished floor shall be covered with stainless steel. Side and rear walls from 1220 (48 in.) to the ceiling shall be covered with // high pressure plastic laminate // stainless steel. // Apply directly to the cab walls or to 13 mm (1/2 in.) plywood/particle board that meets requirements of ASTM E 84, UL 723, and CAN/ULC-S102.2, whichever is applicable. Submit a method of fastening plywood/particle board to steel walls. It shall be flush with the face of the bottom section of the stainless steel. Plastic laminate shall comply with Federal Specification L-P-508, Style Type 1, and Class 1. Color is specified in Section 09 06 00, SCHEDULE FOR FINISHES, Interior shall be flush panel construction with angles welded on exterior to ensure adequate rigidity. Coat exterior of panels with mastic sound insulation material approximately 2.5 mm (3/32 in.) thick followed by a prime coat of paint. Mastic material shall conform to ASTM E1042.

  1. Smooth and flush all joints with no ragged or broken edges. Plastic laminate shall comply with NEMA LD-3, textured finish, general purpose type, grade designation GP 50, and 0.050 in. thickness, except with a minimum wear resistance of 1200 cycles, and backer sheet, grade designation BK 20, and 0.020 in. thickness.

G. Provide a hinged top emergency exit cover. Exit shall be unobstructed when open and shall have mechanical stops on the cover. Provide a code approved exit switch to prevent operation of the elevator when the emergency exit is open.

H. Provide duplex, GFCI protected type receptacle in car. Locate flush-mounted receptacle on the centerline of the main car operating panel, 150 mm (6 in.) above the car floor.

I. Lighting for passenger elevators:

  1. Provide //stainless steel // aluminum // hanging ceiling frame. Construct frame of 1/8 in. x 1 1/2 in. x 1 1/2 in. “T” and “L” sections, divide ceiling into six panels.
  2. Provide fluorescent or LED illuminated car light fixtures above the ceiling panels. See Specification 265100, Interior Lighting for fixture and ballast type. Maintain a minimum light level of 50-foot candles at 914 mm (36 in.) above the finished floor.

J. Lighting for service elevators:

  1. Provide car lighting with indirect fluorescent or LED lamps mounted in lighting coves along each side of the cab ceiling, front to back.
  2. Equip the lighting cove with asymmetrical polished aluminum reflectors having a specular anodized finish. Maintain a minimum light level of 50-foot candles 914 mm (36 in.) above finished floor at the car operating panels.

3. Enclose the entire vertical space between the light trough outer edge and the cab canopy with approved opaque white or clear lumicite sheeting. Install the lumicite sheeting so that it is removable for cleaning and re-lamping.

K. Provide a blower unit arranged to exhaust through an opening in the canopy. Provide a stainless or chrome plated fan grill around the opening. Provide 2-speed fan, capable of rated free delivery air displacement of approximately 380 and 700 cfm at respective speeds. Mount fan on top of car with rubber isolation to prevent transmission of vibration to car structure. Provide screening over intake and exhaust end of blower. Provide a 3-position switch to control the unit in the service panel.

L. Provide car enclosure with two sets of stainless steel handrails.

1. 75 mm (3 in.) wide x 9 mm (3/8 in.) thick flatstock located with centerlines 750 mm and 1050 mm (30 in. and 42 in.) above the car floor.
2. Locate handrails 38 mm (1 1/2 in.) from cab wall. Install handrails on // two side and rear walls // two sides //. Curve ends of handrails to walls. Conceal all handrail fastenings. Handrails shall be removable from inside the car enclosure.

M. Provide car entrance with variable speed, center opening sliding car doors, of same type as hoistway doors for Elevators. Construct door panels to be flush hollow metal construction, not less than 32 mm (1 1/4 in.) thick, consisting of one continuous piece 16-gauge stainless steel on car side face wrapped around the leading and trailing edges. Separate two plates by a sound-deadening material, and reinforce by steel shapes welded to the plates at frequent intervals. Reinforce panels as required for installation of hangers, power-operating and door-opening devices. Hang doors on two-point suspension hangers having sealed ball-bearing sheaves not less than 76 mm (3 in.) in diameter, with rubber or non-metallic sound-reducing tires. Equip hangers with adjustable ball-bearing rollers to take upward thrust of panels. Upthrust rollers shall be capable of being locked in position after adjustment to a maximum of .38 mm (1/64 in.) clearance. Provide two laminated phenolic gibs on each door panel. Gibs shall be replaceable without removal of door panel. Provide door drive assembly, restrictor, gate switch, header, track, arms, and all related door hardware.

2.52 POWER DOOR OPERATORS: PASSENGER/SERVICE ELEVATORS

A. Provide a high-speed heavy duty door operator to automatically open the car and hoistway doors simultaneously when the car is level with the floor, and automatically close the doors simultaneously at the expiration of the door-open time. Provide solid-state door control with closed loop circuitry to constantly monitor and automatically adjust door operation based upon velocity, position, and motor current. Motor shall be of the high-internal resistance type, capable of withstanding high currents resulting from stall without damage to the motor. The door operator shall be capable of opening a car door and hoistway door simultaneously, at a speed of .762 m (2.5 ft) per second. The closing speed of the doors shall be .3 m (1 ft) per second. A reversal of direction of the doors from the closing to opening operation, whether initiated by obstruction of the infrared curtain or the door "OPEN" button, shall be accomplished within 38 mm (1.5 in.) maximum of door movement. Emphasis is placed on obtaining quiet interlock and door operation; smooth, fast, dynamic braking for door reversals, stopping of the door reversal, and stopping of the doors at extremes of travel. Construct all levers and drive arms operating the doors, of heavy steel members, and all pivot points shall have ball or roller bearings.

B. Hoistway doors and car gates shall be manually operable in an emergency without disconnecting the power door operating equipment unless the car is outside the unlocking zone.
   1. It shall not be possible for the doors to open by power unless the elevator is within the leveling zone.
   2. Provide infrared curtain unit. The device shall cause the car and hoistway doors to reverse automatically to the fully-open position should the unit be actuated while the doors are closing. Unit shall function at all times when the doors are not closed, irrespective of all other operating features. The leading edge of the unit shall have an approved black finish.

C. Should the doors be prevented from closing for more than a predetermined adjustable interval of 20 to 60 seconds by operation of the curtain unit, the doors shall stay open, the audio voice message and a buzzer located on the car shall sound only on automatic operation. **Do not provide door nudging.**
   1. If an obstruction of the doors should not activate the photo-electric door control device and prevent the doors from closing for more than a predetermined adjustable interval of 15 to 30 seconds, the doors shall reverse to the fully open position and remain open until the “Door Close” button re-establishes the closing cycle.

D. Provide door "OPEN" and "CLOSE" buttons. When the door "OPEN" button is pressed and held, the doors, if in the open position, shall remain open and if the doors are closing, they shall stop, reverse and re-open. Momentary pressure of the door "CLOSE" button shall initiate the closing of the doors prior to the expiration of the normal door open time.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine work of other trades on which the work of this Section depends. Report defects to the Resident Engineer in writing that may affect the work of this trade or equipment operation dimensions from site for preparation of shop drawings.

B. Ensure that shafts and openings for moving equipment are plumb, level and in line, and that pit is to proper depth, waterproofed and drained with necessary access doors, ladder and guard.

C. Ensure that machine room is properly illuminated, heated and ventilated, and equipment, foundations, beams correctly located complete with floor and access stairs and door.

D. Before fabrication, take necessary job site measurements, and verify where work is governed by other trades. Check measurement of space for equipment, and means of access for installation and operation. Obtain dimensions from site for preparation of shop drawings.

E. Ensure the following preparatory work, provided under other sections of the specification has been provided. If the Elevator Contractor requires changes in size or location of trolley beams or their supports and trap doors, etc., to accomplish their work, he must make arrangements, subject to approval of the Contracting officer, and include additional cost in their bid. Where applicable, locate controller near and visible to its respective hoisting machinery. Work required prior to the completion of the elevator installation:
   1. Supply of electric feeder wires to the terminals of the elevator control panel, including circuit breaker.
   2. Provide light and GFCI outlets in the elevator pit and machine room.
   3. Furnish electric power for testing and adjusting elevator equipment.
   4. Furnish circuit breaker panel in machine room for car and hoistway lights and receptacles.

5. Supply power for cab lighting and ventilation from an emergency power panel specified in Division 26, ELECTRICAL.
6. Machine room enclosed and protected from moisture, with self closing, self locking door and access stairs.
7. Provide fire extinguisher in machine room.

F. Supply for installation, inserts, anchors, bearing plates, brackets, supports and bracing including all setting templates and diagrams for placement.

3.2 SPACE CONDITIONS

A. Attention is called to overhead clearance, pit clearances, overall space in machine room, and construction conditions at building site in connection with elevator work. Addition or revision of space requirements, or construction changes that may be required for the complete installation of the elevators must be arranged for and obtained by the Contractor, subject to approval by Resident Engineer. Include cost of changes in bid that become a part of the contract. Provide proper, code legal installation of equipment, including all construction, accessories and devices in connecting with elevator, mechanical and electrical work specified.

B. Where concrete beams, floor slabs, or other building construction protrude more than 50 mm (2 in.) into hoistway, bevel all top surfaces of projections to an angle of at 75 degrees with the horizontal.

3.3 INSTALLATION

A. Perform work with competent Certified Elevator Mechanics and Apprentices skilled in this work and under the direct supervision of the Elevator Contractor’s experienced foreman.

B. Set hoistway entrances in alignment with car openings, and true with plumb sill lines.

C. Erect hoistway sills, headers and frames prior to erection of rough walls and doors. Erect fascias and toe guards after rough walls are finished.

D. Install machinery, guides, controls, car and all equipment and accessories in accordance with manufacturer’s instructions, applicable codes and standards.

E. Isolate and dampen machine vibration with properly sized sound-reducing anti-vibration pads.

F. Grout sills and hoistway entrance frames.

3.4 ARRANGEMENT OF EQUIPMENT

A. Clearance around elevator, mechanical and electrical equipment shall comply with applicable provisions of NEC. Arrange equipment in machine room so that major equipment components can be removed for repair or replacement without dismantling or removing other equipment in the same machine room. Locate controller near and visible to its respective hoisting machine.

3.5 WORKMANSHIP AND PROTECTION

A. Installations shall be performed by Certified Elevator Mechanics and Apprentices to best possible industry standards. Details of the installation shall be mechanically and electrically correct. Materials and equipment shall be new and without imperfections.

B. Recesses, cutouts, slots, holes, patching, grouting, refinishing to accommodate installation of equipment shall be included in the Contractor’s work. All new holes in concrete shall be core drilled.

C. Structural members shall not be cut or altered. Work in place that is damaged or defaced shall be restored equal to original new condition.

D. Finished work shall be straight, plumb, level, and square with smooth surfaces and lines. All machinery and equipment shall be protected against dirt, water, or mechanical injury. At final completion, all work shall be thoroughly cleaned and delivered in perfect unblemished condition.

E. Beams, slabs, or other building construction protruding more than four inches into the hoistway, all top surfaces shall be beveled at an angle of at least 75 degrees to the horizontal.

F. Sleeves for conduit and other small holes shall project 50 mm (2 in.) above concrete slabs.

G. Hoist cables that are exposed to accidental contact in the machine room and pit shall be completely enclosed with 16-gauge sheet metal or expanded metal or guards.

H. Exposed gears, sprockets, and sheaves shall be guarded from accidental contact in accordance with ASME A17.1 Section 2.10.

3.6 CLEANING

A. Clean machine room and equipment.

B. Perform hoistway clean down.

C. Prior to final acceptance; remove protective coverings from finished or ornamental surfaces. Clean and polish surfaces with regard to type of material.

3.7 PAINTING AND FINISHING

A. Hoist machine, motor, shall be factory painted with manufacturer’s standard finish and color.

B. Controller, sheave, car frame and platform, counterweight, beams, rails and buffers, except their machined surfaces, cams, brackets and all other uncoated ferrous metal items shall be painted one factory priming coat or approved equal.

C. Upon completion of installation and prior to final inspection, all equipment shall be thoroughly cleaned of grease, oil, cement, plaster and other debris. All equipment, except that otherwise specified as to architectural finish, shall then be given two coats of paint of approved color, conforming to manufacturer’s standard.

D. Field painting of governors shall be in accordance with ASME A17.1 Rule 2.18.3.1.

E. Stencil or apply decal floor designations not less than 100 mm (4 in.) high on hoistway doors, fascias or walls within door restrictor areas as required by ASME A17.1 Rule 2.29.2. The color of paint used shall contrast with the color of the surfaces to which it is applied.

F. Elevator hoisting machine, controller, governor, main line shunt trip circuit breaker, safety plank, and cross head of car shall be identified by 100 mm (4 in.) high numerals and letters located as directed. Numerals shall contrast with surrounding color and shall be stenciled or decaled.

G. Hoistway Entrances of Passenger, and Service Elevators:

1. Door panels shall be parkerized or given equivalent rust resistant treatment and a factory finish of one coat of baked-on primer and one factory finish coat of baked-on enamel.
2. Fascia plates, top and bottom shear guards, dust covers, hanger covers, and other metalwork, including built-in or hidden work and structural metal, (except stainless steel entrance frames and surfaces to receive baked enamel finish) shall be given one approved prime coat in the shop, and one field coat of paint of approved color.

I. Elevator Cabs for Passenger and Service Elevators:

1. Interior and exterior steel surfaces shall be parkerized or given equivalent rust resistant treatment before finish is applied.

2. Interior steel surfaces shall be factory finished with one coat of baked on enamel or proxylin lacquer. For color, see Section 09 06 00, SCHEDULE FOR FINISHES.
3. Give exterior faces of car doors one finish coat of paint of medium gray color.

3.8 PRE-TESTS AND TESTS

A. Pre-test the elevators and related equipment in the presence of the Resident Engineer or his authorized representative for proper operation before requesting final inspection. Conduct final inspection at other than normal working hours, if required by Resident Engineer.
   1. Procedure outlined in the Inspectors Manual for Electric Elevators, ASME A17.2 shall apply.
      a. Final test shall be conducted in the presence of and witnessed by an ASME QEI-1 Certified Elevator Inspector.
      b. Government shall furnish electric power including necessary current for starting, testing, and operating machinery of each elevator.
   2. Contractor shall furnish the following test instruments and materials on-site and at the designated time of inspection: properly marked test weights, voltmeter, amp probe, thermometers, direct reading tachometer, megohm meter, vibration meter, sound meter, light meter, stop watch, and a means of two-way communication.

B. Inspect workmanship, equipment furnished, and installation for compliance with specification.

C. Balance Tests: The percent of counterbalance shall be checked by placing test weights in car until the car and counterweight are equal in weight when located at the mid-point of travel. If the actual percent of counter balance does not conform to the specification, the amount of counterweight shall be adjusted until conformance is reached.

D. Full-Load Run Test: Elevators shall be tested for a period of one hour continuous run with full contract load in the car. The test run shall consist of the elevator stopping at all floors, in either direction of travel, for not less than five or more than ten seconds per floor.

E. Speed Test: The actual speed of the elevator shall be determined in both directions of travel with full contract load, balanced load and no load in the elevator. Speed shall be determined by applying a certified tachometer to the car hoisting ropes or governor rope. The actual measured speed of the elevator with all loads in either direction shall be within three (3) percent of specified rated speed. Full speed runs shall be quiet and free from vibration and sway.

F. Temperature Rise Test: The temperature rise of the hoisting motor shall be determined during the full load test run. Temperatures shall be measured by the use of thermometers. Under these conditions, the temperature rise of the equipment shall not exceed 50 degrees Centigrade above ambient temperature. Test shall start when all machine room equipment is within five (5) degrees Centigrade of the ambient temperature. Other tests for heat runs on motors shall be performed as prescribed by the Institute of Electrical and Electronic Engineers.

G. Car Leveling Test: Elevator car leveling devices shall be tested for accuracy of leveling at all floors with no load in car, balanced load in car, and with contract load in car, in both directions of travel. Accuracy of floor level shall be within plus or minus 3 mm (1/8 in.) of level with any landing floor for which the stop has been initiated regardless of load in car or direction of travel. The car leveling device shall automatically correct over travel as well as under travel and shall maintain the car floor within plus or minus 3 mm (1/8 in.) of level with the landing floor regardless of change in load.

H. Brake Test: The action of the brake shall be prompt and a smooth stop shall result in the up and down directions of travel with no load and rated load in the elevator. Down stopping shall be tested with 125 percent of rated load in the elevator.

I. Insulation Resistance Test: The elevator's complete wiring system shall be free from short circuits and ground faults and the insulation resistance of the system shall be determined by use of megohm meter, at the discretion of the Elevator Inspector conducting the test.

J. Safety Devices and Governor Tests: The safety devices and governor shall be tested as required by ASME A17.1 Section 8.10.

K. Overload Devices: Test all overload current protection devices in the system at final inspection.

L. Limit Stops:

1. The position of the car when stopped by each of the normal limit stops with no load and with contract load in the car shall be accurately measured.
2. Final position of the elevator relative to the terminal landings shall be determined when the elevator has been stopped by the final limits. The lower limit stop shall be made with contract load in the elevator. Elevator shall be operated at inspection speed for both tests. Normal limit stopping devices shall be inoperative for the tests.

M. Oil Buffer Tests: These tests shall be conducted with operating device and limit stops inoperative and with contract load in the elevator for the car buffer and with no load in the elevator for the counterweight buffer. Preliminary test shall be made at the lowest (leveling) speed. Final tests shall be conducted at contract speed. Buffers shall compress and return to the fully extended position without oil leakage.

N. Setting of Car Door Contacts: The position of the car door at which the elevator may be started shall be measured. The distance from full closure shall not exceed that required by ASME A17.1. The test shall be made with the hoistway doors closed or the hoistway door contact inoperative.

O. Setting of Interlocks: The position of the hoistway door at which the elevator may be started shall be measured and shall not exceed ASME A17.1 requirements.

P. Operating and Signal System: The elevator shall be operated by the operating devices provided and the operation signals and automatic floor leveling shall function in accordance with requirements specified. Starting, stopping and leveling shall be smooth and comfortable without appreciable steps of acceleration or deceleration.

Q. Performance of the Elevator supervisory system shall be witnessed and approved by the representative of the Resident Engineer.

R. Evidence of malfunction in any tested system or parts of equipment that occurs during the testing shall be corrected, repaired, or replaced at no additional cost to the Government, and the test repeated.

S. If equipment fails test requirements and a re-inspection is required, the Contractor shall be responsible for the cost of re-inspection; salaries, transportation expenses, and per-diem expenses incurred by the representative of the Resident Engineer.

3.9 INSTRUCTION OF VA PERSONNEL

A. Provide competent instruction to personnel regarding the operation of equipment and accessories installed under this contract, for a period equal to one eight hour day. Instruction shall commence after completion of all work and at the time and place directed by the Resident Engineer.

B. Written instructions in triplicate relative to care, adjustments and operation of all equipment and accessories shall be furnished and delivered to the Resident Engineer in independently bound folders. DVD recordings will also be acceptable. Written instructions shall include correct and legible wiring diagrams, nomenclature sheet of all electrical apparatus including location of each device, complete and comprehensive sequence of operation, complete replacement parts list with descriptive literature, and identification and diagrammatic cuts of equipment and parts. Information shall also include electrical operation characteristics of all circuits, relays, timers, and electronic devices, as well as R.P.M. values and related characteristics for all rotating equipment.

C. Provide supplementary instruction for any new equipment that may become necessary because of changes, modifications or replacement of equipment or operation under requirements of paragraph entitled "Warranty of Construction".

3.10 INSPECTIONS AND SERVICE: GUARANTEE PERIOD OF SERVICE

A. Furnish complete inspection and maintenance service on entire elevator installation for a period of one (1) year after completion and acceptance of all the elevators in this specification by the Resident Engineer. This maintenance service shall run concurrently with the warranty. Maintenance work shall be performed by Certified Elevator Mechanics and Apprentices employed and supervised by the company that is providing guaranteed period of service on the elevator equipment specified herein.

B. This contract will cover full maintenance including emergency call back service, inspections, and servicing the elevators listed in the schedule of elevators. The Elevator Contractor shall perform the following:

1. Bi-weekly systematic examination of equipment.
2. During each maintenance visit the Elevator Contractor shall clean, lubricate, adjust, repair and replace all parts as necessary to keep the equipment in first class condition and proper working order.
3. Furnishing all lubricant, cleaning materials, parts and tools necessary to perform the work required. Lubricants shall be only those products recommended by the manufacturer of the equipment.
4. Equalizing tension, shorten or renew hoisting ropes where necessary to maintain the safety factor.
5. As required, motors, controllers, selectors, leveling devices, operating devices, switches on cars and in hoistways, hoistway doors and car doors or gate operating device, interlock contacts, guide shoes, guide rails, car door sills, hangers for doors, car doors or gates, signal system, car safety device, governors, tension and sheaves in pit shall be cleaned, lubricated and adjusted.
6. Guide rails, overhead sheaves and beams, counterweight frames, and bottom of platforms shall be cleaned every three months. Car tops and machine room floors shall be cleaned monthly. Accumulated rubbish shall be removed from the pits monthly. A general cleaning of the entire installation including all machine room equipment and hoistway equipment shall be accomplished quarterly. Cleaning supplies and vacuum cleaner shall be furnished by the Contractor.
7. Maintain the performance standards set forth in this specification.
8. The operational system shall be maintained to the standards specified hereinafter including any changes or adjustments required to meet varying conditions of hospital occupancy.
9. Maintain smooth starting and stopping and accurate leveling at all times.

C. Maintenance service shall not include the performance of work required as a result of improper use, accidents, and negligence for which the Elevator Contractor is not directly responsible.

D. Provide 24 hour emergency call-back service that shall consist of promptly responding to calls within two hours for emergency service should a shutdown or emergency develop between regular examinations. Overtime emergency call-back service shall be limited to minor adjustments and repairs required to protect the immediate safety of the equipment and persons in and about the elevator.

E. Service and emergency personnel shall report to the Resident Engineer or his authorized representative upon arrival at the hospital and again upon completion of the required work. A copy of the work ticket containing a complete description of the work performed shall be given to the Resident Engineer or his authorized representative.

F. The Elevator Contractor shall maintain a log book in the machine room. The log shall list the date and time of all weekly examinations and all trouble calls. Each trouble call shall be fully described including the nature of the call, necessary correction performed or parts replaced.

G. Written “Maintenance Control Program” shall be in place to maintain the equipment in compliance with ASME A17.1 Section 8.6.

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SECTION 21 05 00

COMMON WORK RESULTS FOR FIRE SUPRESSION

PART 1 GENERAL

1.1 General Requirements

1.1.1 The work of Division 21 shall be governed by general conditions of contract and sections of Division - 21 .

1.1.2 It is the Contractors responsibility to be fully aware of and comply with all of the requirements of the above documents, and further assure that all Subcontractors are equally informed.

1.2 Application

1.2.1 This section applies to and is part of all Sections of Division 21

1.3 Scope of Works

1.3.1 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 for the completion of those Works shall be provided.

1.3.2 Any NFPA or Civil Defense requirement or approval shall be the Contractor responsibility and shall be included in the Tender price and any future requirement either shown on the drawings or specifications, shall be done without any additional cost implication to original contract.

1.3.3 All Fire Fighting work shall be carried out by Specialist approved by Civil Defense and it is the Contractor responsibility to obtain Civil Defense drawings approval before the work commence.

1.3.4 Piping shall be pitched to permit complete draining of the system.

1.3.5 Fire standpipe shall not be used in any way to provide water for other purposes.

1.3.6 All valves and risers shall be securely supported at each floor.

1.3.7 All valves and risers shall be located where readily accessible.

1.3.8 All local alarms shall be linked with the electrical fire control panel as shown on drawings and or specified in such a way that whenever any local alarm is initiated, a corresponding pilot and alarm shall be actuated on the main fire control panel to indicate occurrence of fire in the particular zone.

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1.4 Quality Assurance

1.4.1 The manufacturers of all materials and equipment must have at least ten years of experience in the design and manufacture of their products

1.5 Related Works Specified Elsewhere

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

Section 1044 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section 21 0523 - General Duty Valves for Fire Suppression Piping
Section 21 0529 - Hangers and Supports for Fire Suppression Piping
Section 21 0548 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
Section 21 05 53 - Identification for Fire Suppression System
Section 21 1226 - Fire Suppression Valve and Hose Cabinet
Section 21 13 13 - Wet Pipe Sprinkler System
Section 21 2000 - Fire Extinguishing Systems
Section 21 30 00 - Fire Pumps
Section 21 40 00 - Fire Suppression Water Storage

1.6 Approvals

1.6.1 No item shall be installed in breach of any of the existing local fire department regulations. In all cases, however, installation shall comply with National Fire Codes (NFPA Latest Edition) or indicated otherwise.

1.7 Engineer's Drawings

1.7.1 The Drawings are based on design and include general layouts and typical details of various systems to be installed. The Contractor shall make the installations in a work man like manner to conform to the structure, to avoid obstructions, to preserve head room, and to keep openings and passage ways clear without additional instruction and without additional cost to the owner.

1.8 Shop Drawings and Data to be Submitted for Approval

1.8.1 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. Shop Drawings scale shall be *1/10, 1/20, 1/50* and *1/100* as applicable and as approved by the Engineer.

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

1.8.3 The Contractor shall submit at the beginning of the project a schedule of submittals for materials and shop drawings to the approval of the Engineer.

1.9 **Approved Material**

1.9.1 All materials shall be furnished in accordance with the requirements of the Specifications.

1.9.2 The naming of manufacturers in the Specifications shall be strictly adhered to in all circumstances.

1.9.3 Substitution of materials other than those named shall not be submitted.

1.9.4 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.

1.9.5 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.

1.10 **Abbreviations**

1.10.1 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, American Standards Association.
ASH RAE	American Society of Heating Refrigeration and Air Conditioning Engineers.
ASME	American Society of Mechanical Engineers.
AWWA	American Water Work Association.
ASTM	American Society for Testing and Materials.
LPC	Loss Prevention Council.
BSI	British Standards Institution.
SMACNA	Sheet Metal and Air Conditioning Contractors National Association.
NFPA	National Fire Protection Association.
UL	Under Writers Laboratories.
BTU	British Thermal Units.
NPC	National Plumbing Code.

1.11 1.11 **Workmanship**

1.11.1 All workmanship required to accomplish the work mentioned in Mechanical specification or shown on related Drawings, shall conform to the highest standards, and as required by the Engineer.

1.11.2 The Engineer will be the sole judge of the standards require.

PART 2 EXECUTION

2.1 Cleaning and Adjusting

2.1.1 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.

2.2 **Tests**

2.2.1 All piping and equipment shall be tested as specified under the corresponding section of the Specifications and to meet local and specified requirements. Labor, materials, power, etc .., required for testing, shall be furnished by the Contractor, unless otherwise indicated under the particular section of the Specifications.

2.2.2 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.

2.2.3 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.

2.2.4 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.

2.2.5 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.

2.2.6 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.

2.2.7 The following tests should be furnished for but limited to the following Fire Suppression System Test.

2.3 Coordination of Trades

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

2.4 Permits

2.4.1 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.

2.4.2 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.

2.4.3 After the pipe lines have been tested and approved, backfill shall be compacted thoroughly by hand tampers below center lines of pipes and to at least 300mm 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 or gravel above the top of piping and hubs.

End of Section 21 05 00.

SECTION 21 05 19

METERS AND GAUGES FOR FIRE SUPPRESSION SYSTEMS

SECTION 21 05 19

METERS AND GAUGES FOR. FIRE SUPPRESSION SYSTEMS

PART 1 GENERAL

1.1 Approvals

1.1.1 No items shall be installed in breach of any of the existing local Fire Department regulations. In all access, however, installation shall comply with National Fire Codes (NFPA latest editions).

1.2 Requirements

1.2.1 Supply and install wherever shown on the drawings all materials specified in the capacities and ratings indicated on the drawings.

1.3 Related Work Specified Elsewhere

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

Section 10 44 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop for Fire Suppression Piping
Section 21 0523 - General Duty Valves for Fire Suppression Piping
Section 21 0529 - Hangers and Supports for Fire Suppression Piping
Section 21 0548 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
Section 21 05 53 - Identification for Fire Suppression System
Section 21 1200 - Fire Suppression Stand Pipes
Section 21 13 00 - Fire Suppression Sprinkler Systems
Section 21 20 00 - Fire Extinguishing Systems
Section 21 3000 - Fire Pumps
Section 21 40 00 - Fire Suppression Water Storage

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
1. Underwriters Laboratories	UL	-	-
2. National Fire Protection Association	NFPA	-	-
3. Loss Prevention Council	LPC	-	THE LPC rules for automatic sprinkler installations

PART 2 PRODUCT

2.1 Pressure Gauges

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

2.1.2 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.

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

2.1.4 Socket shall be Stainless steel.

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

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

2.2 Flow Meters

2.2.1 Supply and install flow meters at the pump test flow line, as shown on drawings. The meter connections and cocks shall be carried well above the line. Install the flow meters in accordance with the manufacturer's recommendation, as per Authority and Fire Department regulations.

<u>End Section 21 05 19.</u>

SECTION 21 05 23

GENERAL DUTY VALVES FOR FIRE SUPPRESSION PIPING

SECTION 21 05 23

GENERAL DUTY VALVES FOR FIRE SUPPRESSION PIPING

PART 1 GENERAL

1.1 General Requirements

1.1.1 Drain valves shall be provided where necessary, where shown on the Drawings and at all sectional valves to help draining the major part of the system. On all risers 4" (100mm) or larger, drain valve shall be 2" (50 mm) size, on 2½" (65 mm) and 3" (80mm) risers, 1¼" (32 mm) valves shall be used and on small risers, ¾" (20mm) drain valves shall be provided.

1.1.2 All valves controlling the water supply shall be located where readily accessible.

1.1.3 Provision shall be made for test connections and valves.

1.1.4 Control power transformer as applicable to limit control voltage to 24 VDC maximum.

1.2 Related Work Specified Elsewhere

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

Section 10 44 00 - Fire Protection Specialists
Section21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section21 0529 - Hangers and Supports for Fire Suppression Piping
Section21 0548 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
Section21 0553 - Identification for Fire Suppression System
Section21 12 00 - Fire Suppression Stand Pipes
Section21 13 00 - Fire Suppression Sprinkler Systems
Section21 20 00 - Fire Extinguishing Systems
Section21 30 00 - Fire Pumps
Section21 4000 - Fire Suppression Water Storage

1.3 Codes and Standards

Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

	Reference Code	Abbreviation	Applicable Standard	Title of Standard
1.	Underwriters Laboratories	UL	-	-

2.	British Standards	BS	BS3169	Specification for first aid reel hoses for firefighting purposes
			BS5839 Part 1	Fire detection and alarm systems for buildings. Code of practice for system design installation and servicing.
3.	National Electrical Manufacturers Association	NEMA	MIG Part 14	
4.	National Electrical Code	NEC	-	-
5.	National Fire Protection Association	NFPA	14	Combined Stand Pipe & Hose System with Sprinklers
6.	National Fire Protection Association	NFPA	13	Sprinkler System
7.	Loss Prevention Council	LPC	-	The LPC rules for automatic sprinkler installations

PART 2 PRODUCTS

2.1 Flow Switch - Electric Type

2.1.1 The water flow alarm device shall consist of an electrical switching device actuated by means of a vane extending inside the pipe so designed that when water flows inside the pipe the moving vane shall close the circuit in the motor switch which shall complete the circuit and actuate an alarm.

2.2 Gear Box and Monitor

2.2.1 Supply and install gear box with internal monitor switch for each monitored type isolating valve in the sprinkler system.

2.2.2 The box and the switch shall be UL listed and approved by FM. The switch shall be two single pole, double throw type and it shall be connected to the BMS and the fire alarm panel so that the movement of the valve disc. from the full open position will register an instantaneous warning in the BMS and fire alarm panel in order to restore the integrity of the system.

2.3 Siamese Connection

2.3.1 Siamese connection shall comply with BS 336 and to be installed where shown on Drawings at a convenient height from finished side walk level and shall be chrome plated extra heavy cast brass complete with the following:

2.3.2 6" x 3" x 3" as shown on drawings Siamese connection with drain cock and check valves to suit local practice.

2.3.3 All chains, caps and screws used for fixing.

2.3.4 Recessed wall box housing the Siamese connection of 2mm stainless steel mirror finish type 316L, GR7 sheet with wired glass door marked in red from inside: "FIRE BRIGADE CONNECTION" in both English and Arabic.

2.4 Branch Orifice

2.4.1 Branch Orifice Plate should be installed as required by LPC or NFPA.

2.4.2 Select orifice flange for circuit flow range and minimum pressure drop across the orifice.

2.4.3 Orifice type of flow station to be inserted between flanges. Cast iron body suitable for operating pressures to 2069 kPa at 121°C. Readout valves of brass construction with integral EPT check valve. Calibration plate mounted on unit.

2.5 Dead Weight Fire Valve & Accessories

2.5.1 Dead Weight Fire Valve & Accessories supply and install wherever shown on the drawing and wherever specified fire valves. The fire valve shall be a weight-operated glandless cast iron rotary plug-type screwed valve, internally lubricated. The valve should not leak, stick or jam, and shall be unaffected by the pressure in the system. The valve shall be suitable for use with pressure up to 1379 x *103M/m2.* (200 Ibs.lsq.in.).

PART 3 EXECUTION

3.1 Cleaning of Piping Systems

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

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

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

3.2 Pipe Installation

3.2.1 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un- insulated lines or of the insulation for insulated pipes.

3.2.2 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.

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

3.2.4 Sleeve construction:

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

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

End Section 21 05 23.

SECTION 21 05 29

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING

PART 1 GENERAL

SECTION 21 05 29

HANGERS AND SUPPORTS FOR FIRE SUPPRESSION PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Related Works Specified Elsewhere

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

1.2 Related Works Specified Elsewhere

Section 22 05 00	-	General Mechanical Requirements for Plumbing
Section 22 05 29	-	Hangers and Supports for Plumbing Piping
Section 2205 53	-	Identification for Plumbing
Section 22 07 00	-	Plumbing Insulation
Section 22 11 16	-	Domestic Water Piping
Section 22 13 00	-	Domestic Water Softeners
Section 22 14 26	-	Facility Storm Drainage
Section 22 14 29	-	Sump Pumps
Section 22 15 00	-	Compressed Air System (Non Medical)
Section 22 33 00	-	Electric Domestic Water Heater
Section 22 3500	-	Domestic Water Heat Exchanger
Section 22 40 00	-	Plumbing Fixtures
Section 2247 13	-	Electric Water Coolers
Section 25 50 00	-	Integrated Automation Facility Controls
Section 23 05 93	-	Testing, Adjusting and Balancing for HVAC
Section 2261 00	-	Compressed Air System For Laboratory For Healthcare Facilities
Section 2262 00	-	Vacuum Systems For Laboratory And Healthcare Facilities
Section 22 63 00	-	Gas System For Laboratory And Healthcare Facilities
Section 22 66 00	-	Chemical - Waste Systems For Laboratory And Healthcare Facilities
Section 226700	-	Processed Water Systems For Laboratory And Health Care Facilities

1.3 Hangers and Supports, Anchors and Guides - General

1.3.1 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.

1.3.2 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 fish plates embedded in the concrete.

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

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

1.3.5 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.

1.3.6 Hangers shall be formed steel clevis type, unless otherwise specified, with adjustable attachment to hanger rod.

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

1.3.8 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.

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

1.3.10 For hanger rods on piping 3/8”(10 mm) thru 2” (50 mm) inclusive use 3/8" (10 mm) rods, and for piping 2½” (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.

1.3.11 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.

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

1.3.13 Where provision for expansion is required, provide pipe roll stands.

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

1.4 Horizontal Piping Support Schedule

1.4.1 For fire protection piping:

.1" & 1¼" (25 & 32 mm) steel pipe ----------------------- 3.7 meter.
.1½" - 8" (40 - 200 mm) steel pipe ------------------------4.6 meter.
.1½" (40 mm) PVC pipe ---------------------------------- 2 meter.
.2" (50 mm) PVC pipe -------------------------------------- 2.5 meter.
.2⅝" (65 mm) PVC pipe ------------------------------------ 2.7 meter.
.3" (80 mm) PVC pipe -------------------------------------- 3.3 meter.

1.4.2 Vertical spacing of PVC pipes shall be twice as those of horizontal spacing.

1.4.3 Vertical spacing of other pipes - at every floor level.

<u>End of Section 21 05 29.</u>

SECTION 21 05 48

MECHANICAL SOUND, VIBRATION, SEISMIC CONTROL FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

SECTION 21 05 48

MECHANICAL SOUND, VIBRATION, SEISMIC CONTROL FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.1 Quality Assurance

1.1.1 The Contractor shall consider all necessary acoustic data to determine the actual surface area to be acoustically treated. Acoustic calculation sheets along with the Contractor's proposals shall be provided, clearly showing that the specified "Reverberation Time" (RT) will be achieved by using the type of acoustic treatment, for the approval of the Engineer.

1.1.2 The Specialist Sub-Contractor should have successfully supplied, installed and completed similar projects for a period of not less than 10 years.

1.2 Related Works Specified Elsewhere

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

Section 10 44 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section 21 05 23 - General Duty Valves for Fire Suppression Piping
Section 21 0529 - Hangers and Supports for Fire Suppression Piping
Section 21 05 53 - Identification for Fire Suppression System
Section 21 12 00 - Fire Suppression Stand Pipes
Section 21 1300 - Fire Suppression Sprinkler Systems
Section 21 2000 - Fire Extinguishing Systems
Section 21 3000 - Fire Pumps
Section 21 40 00 - Fire Suppression Water Storage

1.3 Reference Standards

1.3.1 Reference Standards shall conform to the following performance criteria determined by testing full assemblies (component tests are unacceptable) of identical materials and construction, using factory standard finishes in accordance with relevant codes and standards:-

1.3.2 Fire Performance Characteristics:

1.3.2.1 Provide panels with surface burning characteristics to UBC42-2 and ASTM E-84 by a testing organization approved by the Engineer.

UBC42-2	Fire Hazard Classification	Acceptable
ASTM E84	Fire Hazard Classification	Class-A
Flame Spread		25 or less
Smoke development		450 or less

1.3.3 Acoustics Performance Characteristics:

1.3.3.1 Provide acoustic materials with acoustical absorption characteristics as specified elsewhere by a testing organization acceptable to Engineer. Approved testing authority must be independent of the manufacturer.

1.3.4 Toxicity Characteristics

1.3.4.1 Acoustic materials used in the project should have toxicity characteristics in accordance with article 15, Part 1120 of the New York state uniform fire prevention and building code MEA Classification ME 123-92-M

1.4 Submittals

1.4.1 Shop Drawings

1.4.1.1 Submit to the Engineer, three (3) complete sets of shop drawings prepared on CAD. (Hand produced drawings shall not be acceptable). The drawings shall show all necessary details and dimensions required which will subsequently be field verified and revised as required for the Engineer's approval.

1.4.2 Samples

1.4.2.1 Submit two (2 sets) of the manufacturers samples, 2# samples per set. Each individual panel (wall and ceiling) to be actual size with relevant fixing components for the approval of the Engineer. Product shall be original production material in fabric or vinyl finish as specified.

1.4.3 Certification

1.4.3.1 Submit a certificate of compliance to specify acoustical and fire performance criteria as per this specification, signed by the manufacturer. Attach independent laboratory test results, showing that the products supplied as complete assemblies meeting or exceeding the specified requirements.

1.4.4 Manufacturers Approval

1.4.4.1 The Acoustic Specialist supplying and installing the material shall be an approved agent of the manufacturer. The manufacturer will certify that said contractor is an officially appointed agent having sufficient experience and expertise to complete the project in a satisfactory manner.

1.4.5 Single Source

1.4.5.1 All materials as for as possible shall be from a single supplier.

1.5 Product Delivery, Storage and Handling

1.5.1 Deliver fabricated units and related components to the site for installation to meet a reasonable schedule and to suit the approved project construction program. On-site storage shall be such as to ensure that all panels and associated materials are protected from damage and the outside elements.

1.5.2 Prior to installation the site must be free of wet and dusty trades and the climatic conditions stabilized to normal operational levels. Acoustic e.lements shall be allowed to stabilize on site 24 hours prior to installation.

1.6 Guarantee

1.6.1 The Acoustic Specialist shall furnish in the Client's name, a written guarantee covering the product supplied against defects in materials and workmanship under normal operating conditions for a period of one year from the date of completion of acoustic works .. The Contractor shall pass on to the owner any and all guarantees provided by the manufacturers and acoustic sub-contractor of individual members of the system before the completion of the project.

1.6.2 Provide to the Engineer in the Client's name, sound test results..Sound test results should comply with this specification, which is to achieve the indicated Reverberation Times (RT). The sound test is to form an integral part of the specialist acoustic sub-contractors scope of work.

1.7 Acoustic Design Considerations and Specification

1.7.1 It will be the contractor's responsibility to ensure that the internal acoustic ambient levels are in accordance with this specification.

1.7.2 Where the contractor fails to meet these specifications he will be expected at his own cost, to carry out all remedial work necessary to remedy the situation.

1.7.3 It will be the mechanical services sub-contractor's responsibility to ensure that the noise generated by the plant, including airborne noise through the structure, do not exceed the noise criteria levels for the various types of areas specified.

1.7.4 The Specifications shall be read in conjuncture with the relevant clauses of the Mechanical Specifications Volume 3. In case of any discrepancies the more stringent of the two or as approved by the Engineer shall be applicable..

1.8 Specified Noise Levels

1.8.1 The optimum NC/NR noise levels for the various spaces refer to Table 1 Section 23 0548.

1.8.2 The optimum vibration levels for the various spaces refer to Table 2 - Section 23 0548.

1.8.3 The noise and vibration measurement time parameter (T) shall be representative of the source being measured and at least 1 minute for steady-state noise and vibration sources. If sources are intermittent or cyclic in nature, the noise and vibration measurements shall be of sufficient duration to capture 10 cycles of the source.

1.8.4 It shall be the responsibility of the contractor to ensure that the vibration levels are achieved and to demonstrate and certify that the same have been achieved.

1.9 Noise Attenuation

1.9.1 The Contractor shall supply and fix acoustic insulation, where necessary and as shown on drawings to reduce the airborne noise transmission through Mechanical systems so that the specified noise criteria levels are satisfied.

1.10 External Area Noise

1.10.1 The external noise levels of any installation shall not exceed NC/NR 45 at 3 m at ground and upper levels for normally operating building services plant.

1.10.2 During periodic testing of equipment, noise levels shall. be limited to NC/NR 55 at the site boundaries during daytime testing and NC/NR 45 during night-time testing.

1.11 Vibration Control

1.11.1 All mechanical, Fire Pumps shall be analyzed for vibration and for noise breakout to areas adjacent and above or below to ensure that the specified noise criteria ratings are met.

1.12 Vibration Isolation, Structural Noise and Equipment Bases

1.12.1 The contractor shall be responsible and include for the supply, installation and testing of the complete system necessary for vibration isolation to dampen and eliminate all structure borne vibration generated by the electro-mechanical equipment as described in this specification and as detailed on the scheme drawings.

1.12.2 It is the Contractors responsibility to carry out a full vibration and structure borne noise study as detailed in the mechanical specifications.

1.12.3 Where Fire Fighting equipment units are located at roof level or inside a room the selection of vibration isolation systems shall take into account the effect of the unsupported span between building columns and the subsequent deflection of the slab under the point loads. The spring type isolators shall have a static deflection of not less than 50mm under the load of the units supported. This static deflection is to provide an isolation efficiency of at least 95% and higher deflections are to be used if the calculations so indicate. The Contractor shall also check the installation for airborne noise through the structure that could affect accommodation areas immediately below or adjacent and if necessary recommend the use of acoustic floating floors to contain the noise. A report of the study and recommendations shall be submitted to the Engineer for approval prior to proceeding with the installation. The cost of the study, implementation, erection and any rectification of the original design shall be carried out at the Contractors own cost.

1.12.4 The vibration isolators shall be positioned in accordance with the manufacturer recommendations for the equipment load distribution.

1.12.5 The equipment shall be loaded exactly over or between the mounts without any overhang. The static deflection of the vibration isolators shall be determined by the specialist acoustic

1.12.6 engineer, but should not, be less than that recommended by CIBSE GUIDE or ASHRAE handbook.

1.12.7 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.

1.13 Piping System Vibration Isolators

1.13.1 All piping connected to rotating machinery shall be supported by hangers and supports including vibration isolators and shall be connected to the equipment by means of acoustic flexible connectors.

1.13.2 The first three hangers from the equipment shall provide the same deflection as the equipment isolators; the remaining hangers shall be spring or combination spring and rubber incorporating a spring with at least 20 mm deflection.

PART 2 PRODUCTS

2.1 Isolation Hangers

2.1.1 Refer to Section 21 0529.

2.2 Isolation Mounts

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

2.2.2 Spring Mounts

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

2.2.2.2 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 ..

2.2.2.3 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.

2.3 Inertia Bass

2.3.1 Each Fire pump shall be supported on an Inertia base. Base shall be consist of pre- engineered welded steel frames suitable for concrete pouring, welded-In-concrete reinforcement, equipment mounting bolts and vibration isolator brackets. Base shall mount on spring vibration isolators which shall be of high deflection, free standing, un-housed large diameter, laterally stable steel springs assembled into an upper load plate and leveling assembly and into a lower load plate and noise isolation pad assembly.

PART 3 EXECUTION

3.1 Testing General

3.1.1 The tests of the reverberation time in the areas specified shall be in accordance with (BS5363-1993) "Measurement of Reverberation Time in Building Space and Auditoria".

3.2 Noise Tests

3.2.1 It will be the responsibility of the contractor to employ an independent Acoustic Specialist to carry out proving tests and to prepare noise test certificates for all acoustically important areas of the project.

3.2.2 For items of plant the noise level shall be taken at a point equivalent distance to the largest radiating surface of that equipment.

3.2.3 Tests shall be carried out to establish the required performance standards and shall comply with the sound attenuation recommendations as detailed in the sections below.

3.2.4 Vibration Tests

3.2.4.1 All vibration isolation systems shall allow no more than 5% transmissibility to the structure. 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. The contractor shall bear the cost of rectification of the installations as well as the cost of the specialist services in order to meet the design requirements.

3.3 Hangers and Supports Performance Test

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

End of Section 21 05 48.

SECTION 21 05 53

IDENTIFICATION FOR FIRE SUPPRESSION SYSTEM

SECTION 21 05 53

IDENTIFICATION FOR FIRE SUPPRESSION SYSTEM

PART 1 GENERAL

1.1 Introduction

1.1.1 To be read and governed by general conditions of contract and its Sections. This section includes the identification of all pipe works, equipment etc.

1.2 Scope of Work

1.2.1 The Contractor shall be responsible for submitting complete above works based on specifications and consultant's approval of samples.

1.3 Related Works Specified Elsewhere

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

Section 10 44 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section 21 0523 - General Duty Valves for Fire Suppress-ion Piping
Section 21 0529 - Hangers and Supports for Fire Suppression Piping
Section 21 0548 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.

Section 21 3000 - Fire Pumps
Section 21 4000 - Fire Suppression Water Storage

1.4 Reference Standards

Identification of Pipe lids 1710
BS 4800

Identifications of Pipe Lines and Services
Paint Colors for Building Purposes

PART 2 PRODUCTS

2.1 **Valve Chart Locations**

2.1.1 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.

2.2 Identification of Pipelines and Services

2.2.1 General

2.2.1.1 All Building Services including piping, electrical conduits and their covering shall be properly identified with low emission material as per GREEN/ LEED Guidelines in accordance with BS 1710, Latest Edition.

2.2.1.2 All methods of identification shall be compatible with the pipe and operating conditions.

2.2.1.3 Identification shall be accomplished by using basic identification colors with code indications.

2.2.1.4 Code indication shall include safety colors and service information. Information shall be given regarding the nature of the contents of the pipe by using the following systems, individually or in combination.:-

i. Name in Full.
ii. Abbreviation of Name
iii. Chemical Symbol

2.2.2 Legend

2.2.2.1 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.

2.2.2.2 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.

2.2.2.3 Pipe marking should be highly visible.
The Type & Size of Letters

Outside diameter of pipe or covering (mm)	Length of colour field (mm)	Height of letter (mm)
(13 to 32) mm	200 mm	13 mm
(40 to 50) mm	200 mm	19 mm
(65 to 150) mm	300 mm	32 mm
(200 to 250) mm	600 mm	63 mm
over 250	800 mm	100 mm

2.2.2.4 Colour

2.2.2.4.1 The Colour should be shown on the piping, but in combination with a legend. The application of colour bands shall be done by: Painting, Adhesive colour bands or equivalent colour clips.

2.2.2.4.2 Colour reference shall be in accordance with BS 4800, Latest Edition.

2.2.2.5 Color Code Indication for Building Services and Pipelines should be as follows:

	Basic Colour	Colour Code Identification
Fire Quenching materials (water, FM200, etc.)	Green	Red

2.3 Sign and Accessory Fastening

2.3.1 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.

2.3.2 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.

2.4 Nameplates

2.4.1 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:

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

2.5 Painting

2.5.1 General Requirements

2.5.1.1 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.

2.5.1.2 No painting shall be applied to damp or frosty surfaces in wet, foggy or freezing weather.

2.5.1.3 Paint shall be evenly spread and well brushed out so that there shall be no drops, runs or sagging.

2.5.1.4 Shop coated surfaces shall be cleaned thoroughly and retouched where necessary.

2.5.1.5 Care shall be taken not to paint controls, label plates, nameplates on all apparatus.

2.5.1.6 All items that have rusted or corroded in storage or in place shall be re-cleaned or repainted upon request of the Engineer.

2.5.1.7 Finishing coats shall be made in accordance with a color code, based on BS 1710 and BS
4800 recommendations after being submitted to and approved by the Engineer.

2.5.2 Machinery

2.5.2.1 All machinery installed under this contract such as motors, pumps, etc. shall have a shop priming coat of gray lead and oil.

2.6 Piping

2.6.1 Ferrous piping (galvanized or non-galvanized) 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.

2.6.2 Paint all exposed (in shafts, above and below false ceiling, on roof, etc ..) ferrous piping (including galvanized steel) system components including pipe, fittings, unions, flanges, valves, hangers and supports as follows before wrapping or insulating the pipes (if applicable).

2.6.2.1 Applicable to galvanized pipes:

a. a. Prime Coat: Zinc Chromate.
b. b. Finish Coat: Ironhide gray metal paint or as approved by the Engineer.

Applicable to all other ferrous pipes:

Prime Coat: Red lead Primer, 1.5 to 2.0 mils thick.

2.7 Iron Work

2.7.1 All iron work within the building, not otherwise specified such as pipes hangers and supports, and supports for apparatus, shall be prime painted with one coat of red lead.

End of Section 21 0553.

SECTION 21 08 00

TESTING AND COMMISSIONING OF FIRE SUPPRESSION

PART 1 GENERAL

SECTION 21 08 00

TESTING AND COMMISSIONING OF FIRE SUPPRESSION

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 General Requirements

1.1.1 All piping and equipment shall be tested as specified under the relevant subsection of the specification n.

1.1.2
1.1.3 Labor, materials, instruments, power etc., required for testing shall be furnished by the Contractor unless otherwise indicated under the particular section of the Specification.

1.1.4 Test shall be performed in the presence of representatives of the Engineer and such other parties as may have legal jurisdiction.

1.1.5 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.

1.1.6 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.

1.1.7 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.

1.1.8 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.

1.1.9 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.

1.1.10 When pipes, valves, equipment etc., are to be covered or embedded; 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.

1.1.11 Three copies of all test results shall be submitted to the Engineer.

1.2 Related Work Specified Elsewhere

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

Section 10 44 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section 21 0529 - Hangers and Supports for Fire Suppression Piping
Section 21 0548 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
Section 21 0553 - Identification for Fire Suppression System
Section 21 12 00 - Fire Suppression Stand Pipes
Section 21 13 00 - Fire Suppression Sprinkler Systems
Section 21 2.0 00 - Fire Extinguishing Systems
Section 21 3000 - Fire Pumps
Section 21 4000 - Fire Suppression Water Storage

1.3 Specialized Parties for Testing Balancing and Commissioning

1.3.1 Unless indicated otherwise, major equipment such as Fire Pumps Sets shall be tested and certified as UL listed/ FM approval and Civil Defense Regulations.

1.4 Controls

1.4.1 All controls shall be tested for proper functioning in accordance with the requirements of the Specification.

1.5 Maintenance During Defects Liability Period and Guarantees

1.5.1 Starting from the date of issue of the Substantial/Provisional completion certificate the contractor shall be responsible, for the duration of one year, to provide the following services free of charge, at his own cost-

1.5.1.1 The training of operators assigned by the client for operation of all major equipment and controls as decided by the Engineer. Training should be provided by original suppliers of equipment for a period of at least one week and or when requested by client through out the liability period.

1.5.1.2 The replacement of parts or whole equipment that show any manufacturing or installation defects during operation.

1.5.1.3 Carry out routine preventive maintenance (fortnightly, monthly, quarterly, half yearly and yearly as applicable to the approval of the Engineer) including provision of labor, parts and supply of consumable materials such as Lubricants, required for the safe operation of Fire Pumps and guarantee of performance of all the systems.

1.5.1.4 Necessary staff to carry out the above shall be resident on the job site during the said year. Guarantee of every piece of equipment from any manufacturing or installation defects for

1.5.1.5 a period of one year.

1.5.2 At the end of defects liability period the contractor shall be responsible for final handing over of all installed systems in a perfect condition to the satisfaction of both Engineer and client.

1.6 Extended Defects Liability and Guarantees

1.6.1 The Contractor shall issue in favor of the client all original manufacturers extended guarantees as required by specifications or by Engineers approval conditions or by manufacturers initial proposal prior to final handing over to the client.

1.7 Codes and Standards

1.7.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

	Reference Code	Abbreviation	Applicable Standard	Title of Standard
1.	Underwriters UL Laboratories	UL	-	-
2.	British Standards	BS	BS3169	Specification for first aid reel hoses for firefighting purposes
			BS5423	Specification for portable fire extinguishers.
			BS5839 Part 1	Fire detection and alarm systems for buildings Code of practice for system design installation and servicing
3.	National Manufacturers Association	NEMA	MIG Part 14	-
4.	National Electrical Code	NEC	-	-
5.	National Fire Protection Association	NFPA	-	-
6.	American Water Works Association	AWWA	-	-
7.	Loss Prevention Council	LPC	-	THE LPC rules for automatic sprinklers installations

End of Section 21 0800

SECTION 21 11 00

FIRE SUPPRESSION PIPING

SECTION 21 11 00

FIRE SUPPRESSION PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 General Requirements

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

1.1.2 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.

1.1.3 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.

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

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

1.1.6 Provision shall be made for flushing the system.

1.1.7 All piping shall be installed so that the system may be thoroughly drained.

1.1.8 The piping shall be pitched in the direction of drainage.

1.1.9 Drain valves shall be provided where necessary, where shown on the Drawings and at all sectional valves to help draining the major part of the system. On all risers 4" (100mm) or larger, drain valve shall be 2" (50 mm) size, on 2½" (65 mm) and 3" (80mm) risers, 1¼" (32 mm) valves shall be used and on small risers, ¾" (20mm) drain valves shall be provided.

1.1.10 No direct interconnections shall be made between sewers and fire drain systems.

1.1.11 Fire piping shall not be used, in any way, for domestic water supply purposes.

1.1.12 All valves shall be located where readily accessible.

1.1.13 Provision shall be made for test connections and valves.

1.1.14 Control power transformer as applicable to limit control voltage to 24 VDC maximum.

1.2 Tests

1.2.1 The system shall be subjected to a hydrostatic pressure test, to the satisfaction and in the presence of the Engineer. Pressure shall not be less than 300 psi (2070 KPa) or at 50 psi. (345 KPa) in excess of the maximum static pressure when the maximum static pressure is in excess of 150 psi (1030 KPa) and the test shall be maintained for two hours.

1.2.2 If leaks develop during the test, the contractor shall make all necessary repairs and shall retest the system at no additional cost to the Employer.

1.3 Related Work Specified Elsewhere

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

Section 1044 00 - Fire Protection Specialists
Section 21 05 16 - Expansion Fittings and Loop For Fire Suppression Piping
Section 21 0523 - General Duty Valves for Fire Suppression Piping
Section 21 0529 - Hangers and Supports for Fire Suppression Piping
Section 21 0548 - Mechanical Sound, Vibration, Seismic Control for Fire Suppression Piping and Equipment.
Section 21 05 53 - Identification for Fire Suppression System
Section 21 12 00 - Fire Suppression Stand Pipes
Section 21 1300 - Fire Suppression Sprinkler Systems
Section 21 2000 - Fire Extinguishing Systems
Section 21 30 00 - Fire Pumps
Section 21 40 00 - Fire Suppression Water Storage

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall conform to the applicable portions of the latest editions of the following codes, standards and regulations.

	Reference Code	Abbreviation	Applicable Standard	Title of Standard
1.	Underwriters UL Laboratories	UL	-	-
2.	British Standards	BS	BS3169	Specification for first aid reel hoses for firefighting purposes
			BS5839 Part 1	Fire detection and alarm systems for buildings code of practice for system design installation and servicing
3.	National Manufacturers Association	NEMA	MIG Part 14	-
4.	National Electrical Code	NEC	-	-
5.	National Fire Protection Association	NFPA	14	Combined Stand Pipe and Hose System with Sprinklers
6.	American Water Works Association	AWWA	-	-
7.	Loss Prevention Council	LPC	-	THE LPC rules for automatic sprinkler installations

PART 2 PRODUCTS

2.1 Fire Suppression Pipe

2.1.1 Pipes above ground shall be of the ERW type galvanized steel pipes to B.S. 1387 "medium weight" or ASTM A 53-88a Sch. 40. All pipe fittings elbows, tees, crosses, unions, reducers, etc. shall be of the same quality and weight as the pipes.

2.1.2 Pipe fittings 2" (50 mm) and smaller shall be suitable for threaded connections, *2W'* *(65*mm) and larger shall be flanged ***I*** grooved fittings.

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

2.1.4 Unions shall be used on all screwed pipes and shall be of the same quality and service. Grooved fittings shall be used on all pipes above 2%" and shall be all steel construction to ASTM or BS Standards.

2.1.5 Contractor shall rectify any damage to the pipes from the processes of grooving to the satisfaction of the Engineer.

2.1.6 Pipes underground shall be HOPE to ISO 4427, PE 100 resin all fittings shall be electro fusion and butt fusion types.

PART 3 EXECUTION

3.1 Pipe Installation

3.1.1 Piping shall be pitched to permit complete draining of the system.

3.1.2 Fire standpipe shall not be used in any way to provide water for other purposes.

3.1.3 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un- insulated lines or of the insulation for insulated pipes.

3.1.4 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.

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

3.2 Cleaning of Piping Systems

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

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

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

End Section 21 11 00

SECTION 22 05 00

GENERAL MECHANICAL REQUIREMENTS FOR PLUMBING

PART 1 GENERAL

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

SECTION 22 05 00

GENERAL MECHANICAL REQUIREMENTS FOR PLUMBING

PART 1 GENERAL

1.1 General Requirements

1.1.1 The work of Division 22 shall be governed by general conditions of contract and sections of Division -22.

1.1.2 It is the Contractors responsibility to be fully aware of and comply with all of the requirements of the above documents, and further assure that all Subcontractors are equally informed.

1.2 Application

1.2.1 This section applies to and is part of all Sections of Division 22.

1.3 Scope of Works

1.3.1 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 for the completion of those Works shall be provided.

1.3.2 Unless specifically mentioned otherwise, the following electrical works and materials for the Mechanical equipment shall be supplied and installed under Division 22 of the specification but in all respect to the requirements of the Electrical Specifications.

1.3.2.1 All control panels including door lock disconnected switches, push buttons, starters, contractors, circuit breakers, time delays, selector switches, relays, transformers, timers, controllers, pilot lights, set points, alarms 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.

1.3.2.2 Whenever a number of starters controllers, instruments, indicating lights and the like occur or are shown on the Mechanical and/or electrical Drawings, 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, bus bars, starters, instruments, relays, push-buttons, indicating lights and the like. Components shall be mounted in a logical order based on the sequence of operation.

1.3.2.3 All control equipment including sensors, detectors, actuators, controllers, pressure level and flow switches, annunciation alarms, remote control stations and all such equipment needed for the proper system operation.

1.3.2.4 All control wiring for the above mentioned equipment.

1.3.2.5 Final connection, between disconnect switches, power outlets, flex outlet and mechanical equipment.

1.3.2.6 Power cables between submersible pumps and control panel.

1.3.3 The following electrical works and materials for the mechanical equipment shall be supplied and installed under the electrical part of this contract.

1.3.3.1 All power supply up to and including the following:

1.3.3.2 Disconnect switches when specified to be installed separate from the control panel. Flex outlet for electric water heater.

1.3.3.3 Power supply up to control panels when specified with an integral disconnect switch.

1.3.3.4 Power supply to disconnect switches when the switches are built-in the equipment.

1.3.3.5 Empty conduits with pull wires for all cables and wires classified under the mechanical scope of works.

1.3.3.6 Control outlet boxes for all control equipment classified under the mechanical scope of works.

1.3.3.7 Power cables and conduits or fixing arrangement between water pumps, and their control panel.

1.4 Quality Assurance

1.4.1 The manufacturer's of all materials and equipment must have at least ten years of experience in the design and manufacture of their products.

1.5 Related Work Specified Elsewhere

1.5.1 In addition to the sections mentioned above, and unless specifically called in the specification the following works shall be referred with the other related divisions.

1.6 Engineer's Drawings

1.6.1 The Drawings are based on design 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 head room, and to keep openings and passage ways clear without additional instruction and without additional cost to the owner.

1.7 Shop Drawings and Data to be Submitted for Approval

1.7.1 The Contractor shall submit Shop Drawings showing the exact routing and locations of all the piping, equipment, etc., all in their respective locations and according to the dimensions of the approved manufacturer. Shop Drawings scale shall be *1/10, 1/20, 1/50* and *1/100* as applicable and as approved by the Engineer.

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

1.7.3 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

1.7.4 balancing of the systems. In addition the Contractor shall submit manufacturer's printed installation instructions.

1.7.5 The Contractor shall submit at the beginning of the project a schedule of submittals for materials and shop drawings to the approval of the Engineer.

1.8 Approved Materials

1.8.1 All materials shall be furnished in accordance with the requirements of the Specifications.

The naming of manufacturers in the Specifications shall be strictly adhered to in

all circumstances.

1.8.2 Substitution of materials other than those named shall not be submitted.

1.8.3 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.

1.8.4 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.

1.9 Instruction Period

1.9.1 The Contractor shall be responsible for the training and familiarization of the Employer's Maintenance Staff for a period of at least six weeks on all equipment and plants he has supplied or installed.

1.10 Manual and As-built Drawings

1.10.1 The Contractor shall furnish and submit to the Engineer in electronic and hard copy triplicate bound, A4 size, Instruction Manuals containing the following material.

1.10.2 Brief description of each system and its service and basic operation features.

1.10.3 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.

1.10.4 Chart of the tag numbers, location and function of each valve.

1.10.5 Maintenance instructions for each type of equipment.

1.10.6 Possible breakdowns and repairs for each type of equipment.

1.10.7 List of nearest local suppliers for all equipment.

1.10.8 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.

1.10.9 Complete, as installed, color coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

1.10.10 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

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

1.11 Abbreviations

1.11.1 The following abbreviations have been mentioned in the specifications.

AGA	American Gas Association.
ANSI	American National Standard Institute.
ASA	Acoustical Society of America, American Standards Association
ASME	American Society of Mechanical Engineers.
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association.
BSI	British Standards Institution
NPC	National Plumbing Code
UPC	Uniform Plumbing Code
UL	Under Writers Laboratories

1.12 Workmanship

1.12.1 All workmanship required to accomplish the work mentioned in Mechanical specification or shown on related Drawings, shall conform to the highest standards, and as required by the Engineer.

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

PART 2 PRODUCTS

(NOT USED)

PART 3 EXECUTION

3.1 Cleaning and Adjusting

3.1.1 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.

3.2 Tests

3.2.1 All piping and equipment shall be tested as specified under the corresponding section of the Specifications and to meet local and specified 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.

3.2.2 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.

3.2.3 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.

3.2.4 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.

3.2.5 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.

3.2.6 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.

3.2.7 The following tests should be furnished for but limited to the following:

a. Noise and vibration isolation test
b. Insulation test
c. Sanitary drainage test
d. Pump tests
e. Noise and vibration measurement
f. Water heaters
g. Area storm drainage
h. Domestic water supply test
i. Steam /Condensate pipe test

3.3 Coordination of Trades

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

3.4 Access Doors

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

3.5 Permits

3.5.9 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.

3.5.10 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.

3.6 Openings in Exterior Walls

3.6.1 Openings in exterior walls, particularly at or below grade shall be kept properly plugged and caulked at all times, (except when being worked on) to preclude 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.

3.7 Trench Bottom Grading

3.7.1 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.

3.7.2 After the pipe lines have been tested and approved, backfill shall be compacted thoroughly by hand tampers below center lines of pipes and to at least 300mm 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 or gravel above the top of piping and hubs.

End of Section 220500.

SECTION 22 05 23

GENERAL DUTY VALVES FOR PLUMBING

SECTION 22 05 23

GENERAL DUTY VALVES FOR PLUMBING

PART 1 GENERAL

1.1 General Requirements

1.1.1 Valves shall be installed only in vertical or horizontal positions unless otherwise required by the Drawings.

1.1.2 All valves shall be installed in accessible locations to facilitate easy removal for maintenance.

1.1.3 Valves shall be full-line size.

1.1.4 Valves 2 ½" (65mm) dia. and smaller shall have threaded ends, valves 3" (75) dia. and larger shall have flanged ends.

1.1.5 All threaded end valves shall be installed with unions to facilitate the removal of the valve from the pipeline.

1.1.6 Gate valves shall be installed on both sides of every piece of equipment for all pipe- system connections, and where shown on the Drawings.

1.2 Related Works Specified Elsewhere

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

Section 22 0500 - General Mechanical Requirements for Plumbing
Section 22 07 00 - Plumbing Insulation
Section 22 10 00 - Plumbing Piping and Pumps
Section 22 11 10 - Facility Water Distribution
Section 22 12 00 - Facility Potable Water Storage Tanks
Section 22 13 00 - Domestic Water Softeners
Section 22 14 00 - Facility Storm Drainage
Section 22 33 00 - Plumbing Equipment
Section 22 35 00 - Domestic Water Heat Exchanger
Section 22 40 00 - Plumbing Fixtures
Section 25 50 00 - Pool and Fountain Plumbing System

1.3 Valves Pressure Rating

1.3.1 Unless specified otherwise all valves, strainers, flexible connections, etc. shall be selected for pressure rating at least 1.5 times the operating pressure.

1.3.2 Contractor shall submit a schedule of all valves, strainers, etc., showing the required pressure rating for each fitting and shall indicate its location and service.

1.4 Quality Assurance and Control

1.4.1 All valves shall be kite marked to the applicable B.S. standard.
1.4.2 All valves shall be full line size.
1.4.3 All valves in steam lines shall be suitable for steam application.

PART 2 PRODUCTS

2.1 Gate Valves

2.1.1 Gate valves shall be all bronze with, non rising stem, flanged ends, bolted bonnet and bronze wedge disc faces and seats.

2.1.2 One gate valve shall be supplied and installed:

a. At the supply and return from each equipment.
b. At the discharge and suction of each pump.
c. In general at all points shown on the Drawings and/or specified.

2.1.3 Copper alloy gate valves shall conform to BS 5154.

2.2 Globe Valves

2.2.1 Globe valves shall be all bronze with, flanged ends rising stem, bolted bonnet, renewable composite disc and seat.

2.2.2 Copper alloy globe valves shall conform to BS 5154.

2.3 Check Valves (Spring Loaded Type)

2.3.1 Check valves shall be of the non-slam spring loaded, globe type with the capability to absorb and dampen the shock wave from the piping system water hammer. Check valves 2" (50 mm) and smaller, shall be all bronze, screwed ends. Valves *2W'* (65 mm) and larger, shall be cast iron, flanged ends.

2.3.2 One check valve shall be installed:

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

2.3.3 Copper alloy check valves shall conform to BS 5154.

2.4 Float Valves

2.4.1 Float valves 2" (50 mm) and smaller shall be all bronze, screwed ends, float operated. Valves 2 %" (65 mm) 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.

2.4.2 Copper floats shall conform to BS 1968.

2.5 Automatic Air Vents

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

2.5.2 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 WI (15 mm) lock shield valve shall be directly installed ahead of each automatic air vent, and a ½" (15 mm) drain line shall be provided to discharge at a convenient point.

2.6 Backflow Preventers

2.6.1 This type of valve shall be used on domestic water systems, wherever applicable.

2.6.2 Valve shall combine the double check valve protection *effect* together with an air gap venting to the atmosphere, working on the reduced pressure principle.

2.6.3 Valve shall be suitable for 125 psi (860 Kpa) steam and 200 psi (1380 Kpa).

2.7 Pipe Expansion Joints

2.7.1 Expansion joints shall be provided wherever pipes cross structural expansion joints and wherever required to prevent undue stresses caused by thermal expansion of the pipes.

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

2.7.3 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.

2.8 Ball Valves

2.8.1 Valves shall be cast red bronze, ASTM B584 Alloy 845 ball type for systems other than LPG, with threaded ends, Teflon stem packing seals, Teflon seats, "T" handle for 25 mm and smaller, insulated operating lever for 30mm and larger, and blowout proof silicone bronze stem. Valves shall be rated at 2,750 Kpa water working pressure.

1.9 Balancing Valves

2.9.1 Supply and install balancing valves of double regulating effect with provision for connecting a portable differential pressure meter. Each meter connection shall have pressure temperature read out ports. Valves shall be of the Y-pattern style design which can be installed in any direction without affecting flow measurements.

2.9.2 All valves up to 2" (50 mm) shall be of copper alloy. Valves of 2 ½" (65 mm) and above shall have cast iron body with all other metal parts of nonferrous copper alloy.

2.9.3 Each valve shall provide precise flow measurement, precision flow balancing and positive shut-off with no drip seat and Teflon disc.

2.9.4 Each valve shall have multi-adjustment turns of hand wheel for maximum setting with hidden memory feature to program the valve with precision tamper proof balancing setting. Number of turns shall be 4 for valve up to 2" (50 mm), 8 between 2 ½" (65 mm) and 6" (150 mm), 12 for 8" (200 mm) and 10" (250 mm) and 16 for 12" (300 mm).

2.9.5 All valves up to 2" (50 mm) shall be supplied with polyurethane container.

2.9.6 One set of computerized balancing instrument shall be supplied with the valves. The instruments shall be a read out meter, programmed with the valve curves and with a conversion formula for Cv to read the flow in gpm directly. The instrument shall also be provided with temperature measurement probe.

2.9.7 A chucking device shall hold the valve disconnect firmly and a built-in flat seal shall give it maximum tightness.

2.9.8 The valves shall be globe style design and all metal parts of non-ferrous pressure die- cast, non porous metal: copper alloy.

2.9.9 The valve shall be suitable for installing in any direction without affecting flow measurement and shall provide four functions:

- Precise flow measurement.
- Precision flow balancing
- Positive shut off with no drip seat and Teflon
- disc. Drain connection with protective cap.

2.9.10 The valve shall have four 360 deg. adjustment turns of the hand wheel for maximum venire type setting with hidden memory feature to program the valve with precision tamper-proof balancing setting.

2.10 Water Pressure Reducing Valves

2.10.1 Supply and install wherever shown on the Drawings and as specified here-in-after water pressure reducing valves of the direct operated type.

2.10.2 Each valve shall be constructed of cast iron body, with stainless steel spring and shaft and nylon diaphragm.

2.10.3 The spring shall be designed to provide the pressure reduction indicated on the Drawings.

The valve shall be designed for a work pressure of 1720 KPa and shall be threaded or

flanged ended as the pipe connecting to it.

2.10.4 The valve shall be of the self contained type without any control lines with all internal parts being accessible by removing spring chamber and without dismantling the valve itself.

2.10.5 The valve shall be designed to operate smoothly and quietly without chattering or any water hammer problems.

2.11 Temperature and Pressure Relief Valve

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

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

2.11.3 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 deg.F (100 Deg.C).

2.11.4 Valve shall be AGA and ASME rated.

2.12 Strainers

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

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

2.12.3 Strainers 3" (75 mm) and larger shall be of cast iron body, brass basket and flanged ends.

2.12.4 Basket shall have *1/32″* (0.8 mm.) perforations for water service.

2.13 Flexible Connectors

2.13.1 Flexible 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.

2.14 Double Regulating Valves

2.14.1 Supply and install wherever shown on the drawing and wherever specified double regulating valves.

2.14.2 Valves 2 ½" (65 mm) and below shall be of the screwed in bonnet type of bronze construction. Stem should be rising type of brass construction. Seat shall be brass with regulating disk. Valve shall be complete with double regulating device and BS 21 taper threads (ISO R7).

2.14.3 Valves 3" (75 mm) and larger shall be of cast steel of the outside screw type. Stem shall be rising type of stainless steel. Disk up to 4" (100 mm) diameter shall be stainless and above shall be of 13% Cr. Steel. Gland shall be of stainless steel. Bonnet gasket shall be of CAF according to BS 2815 Gr A. Valve shall be complete with regulating disk, double regulating device and indicator. The valve shall be flanged to BS 4504 table *4/1.*

2.14.4 Temperature and pressure ratings shall be in accordance with BS 5160.

2.15 Accessories (Free Fall Device)

2.15.1 The valve shall be weight-operated with mercury switch devices opens on fusible link failure and shuts off the fuel oil supply pumps and the equipment is feeded by fuel oil such as boilers, incinerators, generators, etc., and so arranged that the weight falls freely, doing no work during the first part of its travel. By the time the weight is called upon to move the valve, it has accumulated sufficient momentum to overcome the inertia of the valve plug. Where pipe run is at low level special linkage should be supplied to raise lower position of dead weight to pipe centre line.

2.15.2 Required length of easy to fit non-corrosive, carefully selected stranded stainless steel cable to hold the valve open or closed as required.

2.15.3 Three brass screw hooks with brass pulleys which automatically align themselves to suit the run of the cable. Two of these shall be woodscrew thread, and one 6mm (",II) B.S.P. thread for fitting to metal surfaces.

2.15.4 Copper tube cable connectors. Where the cable has to be cut and a loop formed, these connectors shall be quick and effective.

2.15.5 One fusible link specially made to break when the temperature reaches a pre-determined point. Normally the link should made to operate at 710C (1600F) as B.S.S. 799 Part5 1975, but other temperature should be catered for when required.

2.15.6 One heavy brass wood-screw threaded eye to secure the far end of the cable to the wall or ceiling.

2.15.7 One engraved warning notice to hang on the cable to prevent people walking into it.

2.16 Thermostatic Mixing Valve

2.16.1 Valve shall be nickel or chrome plated bronze / *brass* construction, Teflon coated valve body wear surface, Teflon coated brass shuttle, EPDM O-Rings, with multiple connection alternatives either sweat union, NPT (Female) union on NPT (Female) connection compression fitting.

2.16.2 Valves shall be for domestic hot water, proportional design (simultaneous control of hot and cold water ports), straight through design (hot and cold ports at same level) ..

2.16.3 The design shall permit easy access for maintenance with replaceable thermostatic element.

2.16.4 Valves shall be capable to supply constant mixed water temperature under different working conditions, it shall have a temperature indicator for accurate control and quick set-up.

2.16.5 Valves shall be ASSE 1070 and ASSE 1017 certified and CSA approved.

2.16.6 Valves shall have the following ratings:

Temperature Range	21°C-49°C
Maximum hot water inlet temperature	100° C
Maximum pressure rating	125 PSI
Maximum Flow	10 GPM
Minimum Flow	0.5 GPM
Maximum allowable & water temperature to avoid scalding	49°C

PART 3 EXECUTION

3.1 Installation of Valves

3.1.1 Valves shall be installed only in vertical or horizontal positions unless otherwise required by the Drawings.

3.1.2 All valves shall be installed in accessible locations to facilitate easy removal for maintenance.

3.1.3 Valves shall be full-line size.
3.1.4 Valves 2" (50 mm) dia. and smaller shall have threaded ends, valves 2 %" (65 mm) dia. and larger shall have flanged ends.

3.1.5 All threaded end valves shall be installed with unions to facilitate the removal of the valve from the pipeline.

3.1.6 Gate valves shall be installed on both sides of every piece of equipment for all pipe-system connections, and where shown on the Drawings.

End of Section 22 05 23.

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 GENERAL

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Hangers and Supports, Anchors and Guides - General

1.1.1 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.

1.1.2 Fasten piping securely to the structure without overstressing any portion of the supports or the structure itself. Secure pipe support, 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.

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

1.1.4 Un-insulated copper or brass pipe and/or tubing shall be isolated from ferrous hangers or supports

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

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

1.1.7 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.

1.1.8 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.

1.1.9 For hanger rods on piping 3/8" (10 mm) thru 2" (50 mm) inclusive use 3/8" (10 mm) rods, and for piping 2 WI (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.

1.1.10 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.

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

1.1.12 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.

1.1.13 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 Ibs (680 Kg) maximum loading provide welded steel bracket.

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

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

1.1.16 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.

1.2 **Horizontal Piping Support Schedule**

1.2.1 Steel and PVC Pipes

- ¾" and 1" (20 and 25 mm) steel pipe-----2.5 meter
- 1 X"-2" (32 and 50 mm) steel pipe-------3.0 meter
- 2 ½"-4" (65 and 100 mm)steel pipe ------4.0 meter
- 5"-6" (125 and 150 mm) steel pipe---------5.0 meter
- 2 ½' (65 mm) and smaller PVC pipe-------1.2 meter
- 3" (80 mm) and over PVC pipe-------------1.8 meter

1.2.2 Vertical spacing of PVC pipes shall be twice as those of horizontal spacing.

1.2.3 Vertical spacing of other pipes - at every floor level.

<u>End of Section 22 0529.</u>

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING

Part 1 GENERAL

1.1 Introduction

1.1.1 Work of this Section to be read and governed by General Conditions of Contract. This Section includes Painting and Identification of all pipe works, equipment etc.

1.2 Scope of Work

1.2.1 The Contractor shall be responsible for submitting complete above works based on specifications and consultant's approval of samples.

1.3 Related Works Specified Elsewhere

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

Section 22 0500	General Mechanical Requirements for Plumbing
Section 22 1000	Plumbing Piping and pumps
Section 22 30 00	Plumbing Equipment
Section 225000	Pool and Fountain Plumbing System

1.4 Reference Standards

BS 1710	Identifications of Pipe Lines and Services
BS 4800	Paint Colors for Building Purposes

Part 2 PRODUCTS

2.1 **Valve Chart Locations**

2.2.1 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.

2.2 Identification of Pipelines and Services

2.2.1 General

2.2.1.1 All Building Services, piping and their covering shall be properly identified with low emission material as per GREEN/ LEED Guidelines in accordance with BS 1710, Latest Edition.

2.2.1.2 All methods of identification shall be compatible with the pipe and operating conditions.

2.2.1.3 Identification shall be accomplished by using basic identification colors with code indications.

2.2.1.4 Code indication shall include safety colors and service information. Information shall be given regarding the nature of the contents of the pipe by using the following systems, individually or in combination:-

i. Name in Full
ii. Abbreviation of Name
iii. Chemical Symbol
iv. Appropriate Code Indication Colour bands.

2.2.2 Legend

2.2.2.1 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.

2.2.2.2 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.

2.2.2.3 <u>Pipe marking should be highly visible.</u>

2.2.3 <u>The Type & Size of Letters</u>

Outside Diameter of pipe or covering (mm)	Length of colour field (mm)	Height of letter (mm)
(13 to 32)	200	13
(40 to 50)	200	19
(65 to 150)	300	32
(200 to 250)	600	63
Over 250	800	100

2.2.4 <u>Colour</u>
2.2.4.1 The Colour should be shown on the piping, but in combination with a legend. The application of colour bands shall be done by: Painting, Adhesive colour bands or equivalent colour clips. Colour reference shall be in accordance with BS 4800, Latest Edition.

2.2.5 <u>Color</u> Code Indication for Building Services and Pipelines should be as follows:

	Basic Colour	Colour Code Identification
- Cold Water	Green	Blue
- Hot Water	Red	Green/White
- Drainage	-	Black
- LPG or Natural Gas	-	Yellow
- Steam	Silver	Grey

2.3 **Sign and Accessory Fastening**

2.3.1 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.

2.3.2 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.

2.4 Nameplates

2.4.1 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:

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

2.5 Painting

2.5.1 <u>General Requirements</u>

2.5.1.1 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.

2.5.1.2 No painting shall be applied to damp or frosty surfaces in wet, foggy or freezing weather.

2.5.1.3 int shall be evenly spread and well brushed out so that there shall be no drops, runs or sagging.

2.5.1.4 Shop coated surfaces shall be cleaned thoroughly and retouched where necessary.

2.5.1.5 Care shall be taken not to paint controls, label plates, nameplates on all apparatus and non-ferrous refrigerant piping.

2.5.1.6 All items that have rusted or corroded in storage or in place shall be re-cleaned or repainted upon request of the Engineer.

2.5.1.7 Finishing coats shall be made in accordance with a color code, based on ASHRAE or BS recommendations after being submitted to and approved by the Engineer.

2.5.2 <u>Machinery</u>

2.5.2.1 All machinery installed under this contract such as motors, pumps, etc. shall have a shop priming coat of gray lead and oil.

2.5.3 <u>Piping</u>

2.5.3.1 All un-insulated and unwrapped Ferrous piping (galvanized or non-galvanized) including flanges, bolts and valves in trench, partitions, below tiles, or underground shall be painted with 2 coats of emulsified asphalt.

2.5.3.2 Paint all exposed (in shafts, above and below false ceiling, on roof, etc ..) ferrous piping (including galvanized steel) system components including pipe, fittings, unions, flanges, valves, hangers and supports as follows before wrapping or insulating the pipes (if applicable).

2.5.3.3 <u>Applicable to galvanized pipes:</u>

a. Prime Coat: Zinc Chromate.
b. Finish Coat: Iron hide gray metal paint or as approved by the Engineer.

2.5.3.4 <u>Applicable to all other ferrous pipes:</u>

Prime Coat: Red lead Primer, 1.5 to 2.0 mils thick.

2.5.4 <u>Iron Work</u>

2.5.4.1 All iron work 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.

<u>End of Section 22 05 53.</u>

SECTION 22. 07 00

PLUMBING INSULATION

SECTION 22 07 00

PLUMBING INSULATION

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and SECTION 22 05 00, requirements.

1.1 Scope of Work

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

1.1.2 All insulation material shall have Zero Ozone Depletion Potential (ODP) and less than Five Global Warming Potential (GWP < 5).

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

1.1.4 Insulation in exposed areas, i.e. permanently visible, shall be protected with aluminium cladding as specified herein after.

1.2 Related Works Specified Elsewhere

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

Section 22 0500 - General Mechanical Requirements for Plumbing
Section 22 10 00 - Plumbing Piping and Pumps
Section 22 30 00 - Plumbing Equipment
Section 25 50 00 - Pool and Fountain Plumbing System

1.3 Schedule of Insulation Thickness

1.3.1 The thickness of the insulation applied to pipes and equipment shall be as follows:-

Service	Location	Pipe Diameter inches (mm)	Insulation Thickness inches (mm)
Boiler, Water Tanks, and Hot water Pumps	-	-	2 (50)
Domestic Cold water Pipes running exposed to sun	-	All sizes for cold water and only larger than 3 (80 mm) for hot water pipes	1(25)
Steam Pipes	-	-	2 (50)
Condensate Steam Pipes	-	-	1 ½(38)
Domestic hot and return Water Pipes	-	Up to 3 (80)	1 (25)

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
National Fire Protection Association	NFPA	NFPA 90A	Standard for Air Conditioning and Ventilating Systems
		NFPA 90B	Standard for warm Air Heating and Air Conditioning Systems
American Society for Testing and Material	ASTM	ASTM E96	Test method for water vapor transmission of materials

PART 2 PRODUCTS

2.1 Pipe Installation

2.1.1 Before installation, the pipe shall be inspected for defects. Defective, damaged or un sound 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.

2.1.2 All drainage and rain water pipes running underground, under the building, shall be encased in concrete for the whole length.

2.2 Pipe Insulation - Type A

2.2.1 This type of insulation shall apply to cold water pipes running on roof and to domestic hot water.

2.2.2 Insulation shall be flexible foamed closed cell elastomeric tubular form type. Insulation may be slipped over pipe or tubing before pipe connections are made, or may be slit longitudinally and snapped onto the pipe and then sealed with vapour barrier adhesive.

2.2.3 Insulation shall have a thermal conductivity not greater than 0.27 BTU / Hr OF. ft sq. per inch thickness at a mean temperature of 75 ° F.

2.2.4 The surface finish shall be an 8-ounce canvas cloth embedded between 2 coats of vapour barrier. Aluminium cladding shall be provided as specified.

2.3 Pipe Insulation - Type B

2. 3.1 This type of insulation shall apply to diesel engine flue pipe.

2. 3.2 Pipe insulation shall be preformed rigid section fibrous glass molded in cylindrical form to fit snugly, sectional one piece construction, with a density of not less than 4 Ibs/ft3 (65 kg/m3) and a max. K-factor of 0.25 Btu.in/Ft2 hr. OF (0.036 W/m.°K) at a mean temperature of

75°F (24°C) side and end laps of jacket shall be pasted down with lapping cement and secured with aluminum bands using a minimum of three bands per block.

2.4 Aluminum Cladding

2. 4.1 Aluminum cladding shall be of 20 gauge, it shall be used as protection against weather and mechanical damage.

2. 4.2 Aluminum cladding shall be applied on top of insulation above the canvas jacket and vapour barrier coating. It shall be held in place by means of self tapping screws and by using 38 mm wide aluminum straps at 300 mm centers with aluminum or stainless steel angle rib clips, all joints shall be sealed with grey coloured suitable sealant. Rivets and screws shall not be used for cladding unless approved by the Engineer for use on elbows and fittings. Cladding shall be overlapping at joints, horizontal seams shall be at the bottom. Cladding on ducts shall be formed in such a way to allow for rain/dew drain *off.*

2. 4.3 Fabricated 20 gauge aluminum covers shall be used for valves and fittings. The covers shall be in two sections hinged together and held in place by suitable stainless steel/aluminum clasps.

2. 4.4 Aluminum cladding shall be applied to all insulated pipes (Galvanized and Pre-insulated) running exposed on roof, outside building, inside parking floors and in plant rooms.

2.5 Protective Coating & Wrapping (Fuel Oil Piping)

2.5.1 Surfaces of pipes shall be thoroughly cleaned to remove rust, mill scale, direct and other loose matter. After the surface is clean and dry, one continuous coat of primer (quick drying) shall be applied and allowed to dry completely. After the surface is fully dry, wrap the pipes with pipeline corrosion tape with backing of black colour or other similar approved wrapping material. Longitudinal overlap should be 25 mm or greater according to the specification and end laps a minimum of 150 mm. Prior to wrap over the fittings, approved molding putty shall be applied.

2.6 Pipe-covering (insulation) protection saddles.

2.6.1 Provide hanger shields to protect vapor sealed pipe insulation within mechanical equipment rooms at each support point by a 360 degree insert of high density, 100 psi, waterproofed calcium silicate encased in a 120 deg..sheet metal shield. Insert thickness shall be same as insulation. Shield length shall equal nominal pipe dia., minimum but shall not be shorter than 100mm and need not be longer than 300mm if 6 bearing load causes no discernable 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.

2.6.2 Provide penetration shields to encase insulated pipes penetrating fire walls or floors in a 360 deg., 24 gauge minimum sheet metal hanger shield with insert of high density, 100 psi. waterproofed calcium silicate the same thickness as 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 asbestos 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.

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

2.7 Pipe Sleeves

2.7.1 Sleeves shall be provided for pipes passing through walls, floors and partitions and be of similar material to pipe except for plastic pipes where sleeves shall be copper or steel.

2.7.2 Sleeves shall be generally one or two sizes larger than pipe as necessary and positioned true with pipe to provide adequate clearance and also allow for lateral movements of pipeline if required.

2.7.3 Sleeves shall be finished flush with finishes face of wall, floor and ceilings, but project 75 mm above floors in wet areas with the cap sealed with waterproof mastic.

2.7.4 Sleeves shall be firs-stopped in gap between pipe and sleeve in all fire rated structures to Building Regulation E14 using asbestos-free fire proof material and without restricting pipework movement (with any thermal insulation sections stopped short each side).

2.7.5 Sleeves shall be caulked in gap between pipe and sleeve in external walls using asbestos-free, weather and vermin proof material.

2.8 Equipment Insulation

2.8.1 This type of insulation shall apply to boilers, boiler circulator, pumps, heat exchangers hot water expansion tanks and domestic hot water tanks.

2.8.1.1 Insulation shall be semi-rigid fibrous glass with organic binder up in board form with a minimum density of 3 Ibs/ft3 (50 kg/m^3) and a maximum K-factor of 0.42 Btu-in/ftz.hr.T (0.06 W/m. °K) at a mean temperature of 200 0F (94°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.

PART 3 EXECUTION

3.1 Protection and Cleaning

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

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

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

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

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

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

3.2 Installation of Piping

3.2.1 All pipe covering 2 ½" (65 mm) or less in thickness shall be applied in single layer with joints tightly butted together.

3.2.2 All pipe covering 3" (80 mm) and larger in thickness shall be double layer with lateral and longitudinal joints of the second layer staggered with those of the first layer. No canvas is to be used between the layers.

3.2.3 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.

3.2.4 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.

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

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

3.2.7 Screwed, soldered, and welded fittings and valves (up to the bonnet) on 4"(100mm) 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 shall be covered to the gland.

3.2.8 Screwed, soldered, and welded fittings and valves (up to the bonnet) up to 4"(100mm) in size shall be covered with field fabricated metered 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.

3.2.9 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 asbestos cement.

3.2.10 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.

3.2.11 Where standard insulation shapes are not available, cut, score or meter 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.

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

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

3.3 Finishes

3.3.1 All pipes running in concealed spaces shall have canvas cover, securely fixed, overlaps firmly pasted down, secured with aluminum bands at intervals and painted with two coats of fire retardant emulsion paint.

3.3.2 All non-c1added pipes running inside building but exposed to view shall have same treatment as for those in concealed spaces but with one coat of gloss paint, to an approved colour, in addition.

3.3.3 Insulation in exposed areas, i.e. permanently visible, shall be protected with aluminum cladding as specified.

<u>End of Section 220700.</u>

SECTION 221116

DOMESTIC WATER PIPING AND FITTINGS

PART 1 GENERAL

PART 4 PRODUCTS

PART 3 EXECUTION

SECTION 221116
DOMESTIC WATER PIPING AND FITTINGS

PART 1 GENERAL

1.1 Introduction

1.1.1 Works of this Section shall be governed by Conditions of Contract and Section 22 05 00.

1.1.2 This section describes basic materials and requirements for Pipework services installations for building.

1.2 Related Works Specified Elsewhere

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

Section 22 05 00 - General Mechanical Requirements for Plumbing
Section 22 07 00 - Plumbing Insulation
Section 22 10 00 - Plumbing Piping and Pumps
Section 22 30 00 - Plumbing Equipments
Section 22 40 00 - Plumbing Fixtures
Section 25 50 00 - Pool and Fountain Plumbing System
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1.3 Storage of UPVC Pipes

1.3.1 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 1.5 m. (or as recommended by the manufacturer) with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

1.4 Pipe Identification

1.4.1 All pipes shall be indelibly marked at intervals of not greater than 3m. The marking shall show the manufacturer's identification, the standard name and number, and the nominal size and class. Adhesive labels alone shall not suffice. All pipes complying with British Standards shall be kite marked.

1.5 Arrangement and Alignment

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

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

1.5.3 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 al 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.

1.6 Storage

1.6.1 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 1.5 m. (or as recommended by the manufacturer) with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

1.7 Codes and Standards

1.7.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
American Water Works Association	AWWA	C601-68 C501-67 M45	FIBERGLASS PIPE DESIGN MANUAL
American Society for Testing and Materials	ASTM	ASTM C425	Specification for compression joint for vitrified clay pipe and fittings
		ASTM A53-88a	Specification for pipes, steel, black and Hot-Dipped, Zinc-Coated, Welded and Seamless
		ASTM B88	Specification for Seamless copper water pipe
		ASTM B280-88	Specification for Seamless copper tube for A/C and refrigeration field Service
		ASTM A307	Specification for Carbon Steel Bolts and Studs. 60,000 psi tensile Strength
		ASTM D1785	Specification for poly (vinyl chloride) (PVC) plastic pipe schedules 40, 80, and 120.
		ASTM D3517M	Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermo-Setting-Resin) Pressure Pipe.
American Standards Association	ASA	ASA 40.1	-
		ASA B16.22	-
		ASA B1618	-
		ASA B9.1	-
		ASA B35.5	-
British Standards	BS	BS 4514	Specification for unplasticized PVC soil and venting pipes, fittings and accessories.

BS 5255	Specification for thermoplastics waste pipe and fittings.
BS 5254	Specification for polypropylene waste pipe and fittings (external diameter 34.6 mm, 41.0 mm and 54.1 mm)
BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water
BS 4346 Part 1	Joints and fittings for use with unplasticized PVC pressure pipes. Injection molded un plasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply.
BS4346 Part 2	Mechanic joints and fittings, principally of unplasticized PVC.
BS 4660	Specification for unplasticized polyvinyl chloride (PVC-U) pipes and plastics fittings of nominal sizes 110 and 160 for below ground gravity, drainage, and Sewerage
BS 5480	Specification for Glass Reinforced Plastic (GRP) Pipes, Joints and Fittings for use of Water Supply or Sewerage.
BS 5481	Specification for unplasticized PVC pipe and fittings for gravity sewers
BS 1387	Specification for screwed and socketed steel tubes and tubular and for plain and steel tube suitable for welding or for screwing to BS21 p
BS 2871	Specification for copper and copper alloys, tubes.
BS 864 PART 2	Specification for capillary and compression fittings for copper tubes.
BS 3601	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure pipes.
BS 21	Specification for pipe threads for tubes and fittings where pressure light joints are made on the threads.

	ASHRAE	-	-
American Society for Heating, Refrigeration, and Air Conditioning Engineers			
Deutches Institute for Normung	DIN	DIN 19534	-
American National Standards Institute	ANSI	ANSI B18.2.2	
		ANSI B31.1	
		ANSI A21, 10, 11	-

PART 2 PRODUCTS

2.1 UPVC Pipes - Type 2

2.1.1 UPVC pipes-Type 2 (Un-plasticized Polyvinyl Chloride) pipes shall be to BS 3505 latest edition Class E 15 Bar (1500 Kpa) working pressure at 68° F (20° C) fluid temperature and 103° F (40° C) ambient temperature or ASTM specification 0 1785 Schedule 40 for inside the buildings, and as per ASTM specification 01785 schedule 80 for the risers.

2.1.2 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.

2.1.3 All fittings and accessories shall be of same material and quality as the pipe and jointing up to 2 W' diameter shall be of the spigot and socket cemented type where solvent cement is applied to both parts all in compliance with B.S. 4346: Part I: 1969 joints and fittings for use with un-plasticized PVC pressure pipes, Part I : Injection molded PVC fittings for solvent welding for use with pressure pipes. After pushing the pipe into the socket, the joint shall be allowed to set for at least 10 hr.

2.1.4 Jointing for all pipes buried underground outside buildings and for all pipes above 3" diameter shall be of the rubber ring integral socket type to BS 4346 Part 2.

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

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

2.1.7 Before bending, the pipe should be heated at the section to be bent to a temperature of about 275-300° F (135-150° C).

2.1.8 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 not be held at the bending temperature too long.

2.2 Cross Linked Polyethylene Pipes (XLPE)

2.2.1 XLPE piping system shall be basically consist of the following components:

2.2.1.1 Cross linked polyethylene pipe pulled in coloured (red for hot water blue for cold water application) corrugated conduits of polyethylene material.

2.2.1.2 Ring main line fittings and valves of bronze or DZR brass construction.

2.2.2 Pipes

2.2.2.1 The inner pipe shall be made of cross linked polyethylene which can withstand up to 95 degree C fluid temperature inside it at a maximum pressure of 10 bars. Pipes shall be able to withstand short time temperature loading up to 110 degree C at a maximum pressure of 10 bars.

2.2.2.2 All pipes shall be stamped at equal intervals with clear marks showing clearly the name of the manufacturer along with the pressure and temperature ratings, pipe diameter and wall thickness, pipe standard DIN *16892/93* and the country of origin of manufacturer.

2.2.2.3 All pipes shall be laid so that they can be easily replaced, whenever necessary by fast and easy pulling from the conduits.

2.2.2.4 Pipes shall satisfy the requirement for drinking water installation and approved by a recognized health organization DVGW or equivalent whenever specifically intended for potable application.

2.2.3 Conduits

2.2.3.1 The conduits shall be made of temperature stabilized high density polyethylene and shall be capable of retaining its form up to 105 degree C. Conduits shall have different colour for different application.

2.2.4 Fittings & Accessories

2.2.4.1 One single line XLPE pipe in one single conduit will supply water to one fixture only from a main ring above false ceiling.

2.2.4.2 Ring feed line shall have an isolating valve of bronze construction. Each pipe at its termination above false ceiling shall be labeled with a tag indicating the fixture it is supplying.

2.2.4.3 Pipes to be connected to the different fittings via a special wall box of reinforced plastic fitted with bronze or DZR brass elbow suitable for "/2" or :y,." threaded connection as required. The box should be suitably designed in order to enable the replacement of existing pipes in the event of their damage (puncturing).

2.2.4.4 All valves, wall box, elbows, tees, bends should be of bronze or DZR brass connections to be of a cone grip unions type allowing full flow capacity, minimum pressure loss, easily detachable with torque clearly defined for a fool proof installation.

2.2.4.5 Contractor to use proper tools for assembly as recommended by manufacturer, i.e. assembly pliers, Ratchet torque wrench, cutters, etc.

2.2.4.6 Distribution ring shall be located above the false ceiling as indicated on the drawings.

2.3 Polypropylene Pipes (PP-R)

2. 3.1 Polypropylene Copolymer Random (PP-R) pipes shall be manufactured according to DIN 8077/8078, fittings shall be manufactured according to DIN 16962.

2. 3.2 Pipes and fittings shall be jointed using electro-fusion welding process. Welding shall be made as recommended by the manufacturer. Threaded fittings shall be used to connect to other piping systems, fixtures, etc., fitting with metal insert shall be sealed with Teflon tape.

2. 3.3 PP-R piping system shall be installed with special pre-caution for thermal expansion

especially for exposed installation.

2. 3.4 Thermal expansion shall be compensated by use of proper elbows, fittings, as recommended by The manufacturer.

2. 3.5 PP-R pipes shall not be installed or stored under direct UV light. Pipes in shafts and roof shall be of multi-layer PP-R aluminum consisting of main pipe PP-R coated with aluminium toil and covered with PP-R film treated to resist long time exposure to UV light. Pipes on roof shall be insulated and cladded.

2. 3.6 Pipe bending shall be generally avoided, in extreme cases pipes may be bent by heating with hot air without direct flames. The minimum bending radius shall be 8 times the pipe diameter.

2. 3.7 PP-R pipes and fittings shall be certified for potable water use by a recognized European Standard, DVGW or approved equivalent.

2. 3.8 Pressure rating of pipes and fittings shall be PN 25. Pipes shall be suitable for working pressure of 10 bars at a working temperature of 60 degree C.

2.4 Flanged Pipe Joints

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

2.4.2 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.

2.4.3 All bolt holes shall be spot faced.

2.5 Joints between Dissimilar Materials

2.5.1 Screwed Pipe to Cast Iron Pipe

2.5.2 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.

2.5.3 Copper Tubing to Screwed Pipe Joints

2.5.4 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.

2.6 Joints Between Dissimilar Metals (Dielectric isolators)

2.6.1 Make joints between ferrous and non-ferrous screwed piping and equipment by using Teflon or nylon isolating materials in the form of screwed unions.

2.6.2 Make joints between ferrous and non-ferrous flanged piping and equipment with insulating gaskets and "Teflon sleeves and washers between flanges, bolts and nuts.

2.6.3 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.

2.7 Fire Stop Collar

2.7.1 Supply and install factory manufactured fire stop collar for all the plastic pipes penetrating fire rated walls and floors. The Collar should be of heavy gauge galvanized metal to house the in tumescent insert. The intumescing shall provide a minimum of ·15 times the free expansion and shall contain no water soluble expansion ingredients and approved to be used in combination with the smoke sealant from the same manufacturer. The collar should be UL classified and FM systems approved to the requirements of ASTM E814 (UL 1479).

2.7.2 The fire sealant should be of non hardening compound, non water soluble ingredients, capable of expanding a minimum of 5 times when subjected to 230 degree F to 100^{o} F. The sealant should be UL classified and FM system approved to the requirements of ASTM E814 (UL 1479).

2.8 Piping Schedule

2.8.1 General

2.8.2 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:

2.9 Hose Bibs

2.9.1 Hose bibs shall be finished ¾" (20 mm) chrome plated brass, compression type with chrome plated handle and standard ¾" (20 mm) male hose connection or otherwise indicated on the Drawings.

2.10 Vacuum Breaker

2.10.1 Where indicated or otherwise required, vacuum breakers shall be installed and set at least

2.10.2 100 mm above the floor level of equipment or fixture rims to prevent contamination of water supply.

2.11 Shock Arrestor (Water Hammer)

2.11.1 Shock arrestor shall be mechanical pneumatic type, stainless steel construction with hermetically sealed bellows and threaded connection.

2.11.2 Arrestors shall be located adjacent to all quick closing valves, solenoid valves, where required and as indicated on Drawings.

2.11.3 Proper sizes shall be determined by the individual application.

2.12 Water Meter

2.12.1 Water meters, 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 (I/s).

2.13 Water Pressure Reducing Valves

2.13.1 Each valve shall be constructed of bronze body, with stainless steel spring and shaft and nylon diaphragm.

2.13.2 The spring shall be designed to provide the pressure reduction indicated on the Drawings.

2.13.3 The valve shall be designed for a work pressure of 250 psi and shall be threaded or flanged ended as the pipe connecting to it.

2.13.4 The valve shall be of the self contained type without any control lines with all internal parts being accessible by removing spring chamber and without dismantling the valve itself.

2.13.5 The valve shall be designed to operate smoothly and quietly without chattering or any water hammer problems.

2.14 Pipe Expansion Joints

2.14.1 Supply and install expansion joints wherever pipes cross structural expansion joints, wherever required to prevent undue stresses caused by thermal expansion of the pipes and wherever expansion cannot be accommodated by natural offsets and changes of direction.

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

2.14.3 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 and as shown on the drawings.

PART 3 EXECUTION

3.1 Arrangement and Alignment of Pipes

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

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

3.1.3 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 paints. However, where obstructions exist, automatic air vents shall be installed at all air pocket points and ½” (15 mm) drain gate valves shall be supplied and installed at all low points and riser legs.

3.2 Special Requirement for PVC Pipe installation

3.2.1 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.

3.2.2 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.

3.2.3 Plumbing vents exposed to sun light shall be protected by water base synthetic latex paints.

3.3 General Requirements for Piping Installation

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

3.3.2 Make all branch connections with tees.

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

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

3.3.5 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.

3.3.6 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.

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

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

3.4 Connection to Equipment and Control Valves

3.4.1 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.

3.4.2 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.

3.5 Hangers, Supports, Anchors And Guides - General

3.5.1 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.

3.5.2 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 fish plates embedded in the concrete.

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

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

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

3.5.6 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.

3.5.7 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.

3.5.8 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.

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

3.5.10 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.

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

3.5.12 For hanger rods on piping 3/8" (10 mm) thru 2" (50 mm) inclusive use 3/8" (10 mm) rods, and for piping 2 ½" (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.

3.5.13 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.

3.5.14 Provide lateral bracing for supporting rods over 4S0mm. long braced at every fourth hanger with diagonal bracing attached to slab or beam.

3.5.15 For floor supports, provide 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.

3.5.16 For wall supports, provide 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 Ibs (680 Kg) maximum loading provide welded steel bracket.

3.5.17 Pipe-covering (insulation) protection saddles.

3.5.18 Provide hanger shields to protect vapor sealed pipe insulation within mechanical equipment rooms at each support point by a 360 degree insert of high density, 100 psi, waterproofed calcium silicate encased in a 120 ° 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 discern able deformation. Insert shall extend 2Smm. 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.

3.5.19 Provide penetration shields to encase insulated pipes penetrating fire walls or floors in a 360°, 24 gauge minimum sheet metal hanger shield with insert of high density, 100 psi. waterproofed calcium silicate the same thickness as 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 asbestos 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.

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

3.5.21 Maximum horizontal spacing for hangers are as follows:

:¾" and 1" (20 and 25 mm) steel pipe--2.5 meter

1 ¼"-2" (32 and 50 mm) steel pipe---3.0 meter
2 ½" -4" (65 and 100 mm)steel pipe ----4.0 meter
5"-6" (125 and 150 mm) steel pipe------5.0 meter
B" (200 mm) and above steel pipe ------6.0 meter
Up to 1 ¼" (32 mm) copper pipe-----2.0 meter

1 3/8" (40 mm) and over copper pipe--3.0

meter
2 ½" (65 mm) and smaller PVC pipe---l.2 meter
3" (80 mm) and over PVC pipe-----"1.8 meter
vertical spacing -PVC pipe-twice as those of hor. Spacing.
-other pipes - at every floor level.

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

3.5.23 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.

3.6 Pipe Sleeves

3.6.1 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un- insulated lines or of the insulation for insulated pipes.

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

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

3.6.4 Sleeve construction:

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

3.6.5 Fill the space between outside of pipe or insulation and the inside of the sleeve or framed opening with fibrous asbestos in interior waifs and floors and pack with oakum, seal with watertight mastic or asphalt in exterior walls.

3.7 Cleaning of Piping Systems

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

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

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

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

3.7.5 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.

3.7.6 During the disinfecting period, care shall be exercised to prevent contamination of water in steel main.

3.8 PIPEWORK CLEARANCES AND SEGREGATION

3.8.1 Minimum clearance between uninsulated pipes, finished face of insulation on pipes and adjacent surfaces shall be as follows:

Walls	25	mm
Ceilings	100	mm
Finished Floors	100	mm
Adjacent pipes, both insulated	25	mm
Adjacent pipes, both uninsulated	25	mm
Insulated pipes adjacent to conduit trunking	100	mm
Uninsulated pipes adjacent to conduit trunking	150	mm
Uninsulated pipes adjacent to electrical cables not in conduit or trunking	150	mm
Insulated pipes adjacent to electrical cables not in conduit or trunking	100	mm

3.8.1 The spacing of services shall provide for the application of thermal insulation and valves and mange boxes and increased spacing to accommodate pipeline fittings.

3.8.2 The spacing of services shall provide for access to pipes and electrical services for ease of installation and maintenance.

3.8.3 The spacing shall be provided for cold water pipes to be away from hot pipes to minimize heat against.

3.9 Material Tests and Identification

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

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

3.10 **Testing**

3.10.1 Water Pipes

3.11.1 Test all domestic water piping system, including valves, fittings and joints under a pressure equal to 100 psig (690 Kpa) or 1 % times the working pressure, whichever is greater.

3.11.2 Blank off or remove all elements such as traps, instruments, automatic valves, diaphragm valve, relief valves, pumps or any other equipment which may be damage by test pressure. Open, but do not back seat, all valves.

3.11.3 Fill the system with water and vent the system at high points to remove air. Maintain the required test pressure for 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.

3.11.4 Repair all leaks or defects uncovered by the tests and retest the system.

3.11.5 After test have been completed, drain the system and blowout and clean it of all dust and/or foreign matters. Clean all strainers, valves and fittings of all dirt, fillings and debris.

3.11 Installation of Unions and Flanges

3.11.1 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.

3.11.2 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.

3.11.3 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.

End of Section 22 11 16.

SECTION 22 11 23

DOMESTIC WATER PUMPS

SECTION 22 11 23
DOMESTIC WATER PUMPS

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Pump Selection & Design Requirements

1.1.1 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 pump selections and the shop drawings are approved.

1.1.2 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.

1.1.3 Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.

1.1.4 Provide shaft packing or seals compatible with the pump design, and in accordance with the manufacturer's recommendations.

1.1.5 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.

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

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

1.2 Related Works Specified Elsewhere

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

Section 22 05 00 - General Mechanical Requirements for Plumbing.
Section 22 07 00 - Plumbing Insulation
Section 22 11 00 - Facility Water Distribution
Section 22 12 00 - Facility Potable Water Storage Tanks
Section 22 13 00 - Facility Sanitary Sewerage
Section 22 30 00 - Plumbing Equipment
Section 22 40 00 - Plumbing Fixtures
Section 22 50 00 - Pool and Fountain Equipment

1.3 Pumping Equipment Operating Characteristics

1.3.1 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.

1.3.2 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.

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

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

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

1.3.6 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.

1.3.7 Motor should be sized to have minimum 20% extra as safety margin on the total power requirements.

PART 2 PRODUCTS

2.1 Variable Speed Pumping Set

2.1.1 For Specification refer to Electrical Specification.

2.2 Vertical Multi-Stage Pumps

2.2.1 Each pump shall be the type specified and shall be directly coupled to an electric motor. Pump body shall be manufactured from high tensile grey iron. Shaft shall be stainless steel and fitted with balance drum to reduce axial loading on motor bearing. Balance drum of stainless steel shall run in bronze bearing in each stage piece. Impeller stage pieces and tie rods shall be constructed of stainless steel.

2.2.2 Pump shall have mechanical seal-slf adjusting type with carbon rotating against a stationary ceramic seal.

2.2.3 Pump/motor coupling shall be manufactured from cold forged steel or cast iron.

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

2.2.4.1. 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 55 type with lockable door,

2.2.4.2. Panel and door shall be rust proof.

2.2.4.3. Panel shall include volt free contractors for connection at BMS 0-10v DC, 4-20 mA

2.2.4.4. Pump speed shall be shown in the pump schedule.

2.3 Centrifugal In-Line Pumps

2.3.1 Casing and back cover shall be manufactured from close-grained cat iron to BS 1452 grade 220. Impeller shall be high-grade gunmetal (bronze) to BS 1400 grade PB3-C. Mechanical seals shall be of the flexible below type having carbon running against a stationary ceramic set with EPDM elastomer component. Shaft shall be high grade stainless steel to BS 970 grade 431 S29.

2.3.2 Motors shall be TEFC to IP54 of the squirrel cage type.

2.4 Water Pressurizing (Booster) Unit

2.4.1 Supply and install wherever shown on the Drawings a pressurizing set comprising a pressure vessel, two pumps (one is standby), interconnecting pipes and valves and all necessary controls to perform proper operation, all as shown on the Drawings.

2.4.2 The unit shall be designed for intermittent operation and suitable for brackish water application. The unit shall be mounted on a base plate and shall be fully tested at the factory before dispatch.

2.4.3 The pressure vessel shall be constructed of welded steel with rubber diaphragm, epoxy complete with:

2.4.3.1 Star delta starter with over load protection.

2.4.3.2 Hand / Auto control switch.

2.4.3.3 Cyclic change over switch, to automatically alternate, duty and standby pump to equalize running time of pumps.

2.4.3.4 Phase failure protection.

2.4.3.5 Alarm circuit with muting button, to provide audible warning of low suction water level.

2.4.3.6 24 volts control circuit with transformer.

2.4.3.7 Low level cut-out installed in the lower water reservoir.

2.4.3.8 Phase reversal relay.

2.4.3.9 Pressure switches, to control starting and stopping of pumps.

2.4.4 The control panel shall be complete with circuit breakers, earth leakage protection as required by the authorities, indicating lights for "Mains On", "Pump Running" and "Motor Tripped", and mains isolator fully interlocked with the front cover.

2.5 Control panel

2.5.1 Electric control panel with circuit breakers, starters, earth leakage protection as required by the authorities, automatic. Electric alternators, indicating lights and selector switches. Panels shall be made of sheet steel of dust and rust proof type with lockable door.

2.5.2 Level control panel wherever shown on drawings and control cables between the level controllers and electric control panel

2.5.3 Panel shall include volt free contacts for connection to BMS 0-10v DC, 4-20mA

PART 3 EXECUTION

3.1 Installation of Pumps

3.1.1 Pumps shall be mounted on bases with isolating pads as specified in the specification.

3.1.2 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.

3.1.3 Pumps shall be secured to bases with proper size anchor bolts.

3.1.4 Drains for packing glands and base shall be piped to nearest drain outlet.

3.1.5 Where corrosion can occur, appropriate corrosion-resistant materials and assembly methods must be used including isolation of dissimilar metals against galvanic interaction.

3.1.6 Provide casing connections for vents, drains, suction and discharge pressure gauges.

3.1.7 Balance impellers and all other moving components statically and dynamically.

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

3.1.9 Install packing rings with alternate layers staggered 90 degrees. Tighten packing for seal while permitting prescribed amount of leakage.

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

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

3.1.12 Coupling guards shall be provided to all pumps.

3.2 Pump Settings

3.2.1 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.

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

3.2.3 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.

3.3 Pumps Testing

3.3.1 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.

3.3.2 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.

3.3.3 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.

3.3.1.1 Water flow, GPM (I/s) at rated head.

3.3.1.2 Shut-off head.

3.3.1.3 Operating Kilowatts from measured voltage, amperes and power factor.

3.4 Spare Parts

3.4.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

3.5 Special Tools

3.5.1 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

3.6 Operation and Maintenance Manuals

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

3.6.1.1 Brief description of each system and its service and basic operation features.

3.6.1.2 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.

3.6.1.3 Maintenance instructions for each type of equipment.

3.6.1.4 Possible breakdowns and repairs for each type of equipment.

3.6.1.5 List of nearest local suppliers for all equipment.

3.6.1.6 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.

3.6.1.7 Complete, as installed, colour coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

3.6.1.8 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

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

3.7 Guarantee and Warranted Period

3.7.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.

3.7.2 AU guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.

3.7.3 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 substantial completion certificate.

3.8 Method of Control of Water Transfer Pumps

3.8.1 Method of Control of Pumps used for Water Supply application.

3.8.2 One pump shall act as a standby (as indicated in the pump schedule).

3.8.3 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.

3.8.4 A float switch installed in the intermediate *I* roof water tank with two pre-determined levels. The high level when reached shall stop the pump automatically and the low level when reached shall start the pump automatically.

3.8.5 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.

<u>End of Section 22 11 23.</u>

SECTION 22 12 00
WATER STORAGE TANKS

SECTION 22 12 00

WATER STORAGE TANKS

PART 1 GENERAL

1.1 Related Documents

1.1.1 Drawings and general provisions of the Contract, including Conditions of Contract and Division 01 Specification Sections, apply to this Section.

1.2 Summary

1.2.1 This Section includes potable-water storage tanks and related specialties and accessories for indoor installations.

1.3 Delivery and Storage

1.3.1 Handle and store water storage tank systems, components, and parts to prevent distortions and other damage that could affect their structural, mechani.cal, or electrical integrity. Replace damaged items that cannot be restored to original condition.

1.3.2 Store items subject to deterioration by exposure to elements, in a well-drained location, protected from weather, and accessible for inspection and handling.

1.3.3 Deliver paint in unopened containers with unbroken seals and labels showing designated name,specification number, color, directions for use, manufacturer, and date of manufacture, legible and intact at time of use.

1.4 Submittals

1.4.1 Product Data: Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories. Indicate dimensions, wall thicknesses, insulation, finishes and coatings,. required clearances, methods of assembly of components, and piping connections.

1.4.2 Manufacturer Seismic Qualification Certification: Submit certification that indicated fibre glass, potable-water storage tanks, accessories, and components will withstand seismic forces defined in Division 15 Section "Mechanical Vibration and Seismic Controls."

1.4.2.1 Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

1.4.2.1.1 The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."

1.4.2.1.2 The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.4.2.2 Dimensioned Outline Drawings of Equipment Unit Identify center of gravity and locate and describe mounting and anchorage provisions.

1.4.2.3 Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

1.4.3 Manufacturer Certificates: For shop inspection and data reports as required by ASME Boiler and Pressure Vessel Code. Confirm successful pressure and leak testing.

1.4.4 Manufacturer Certificates: Confirm successful pressure and leak testing.

1.4.5 Field Test Reports: Indicate and interpret test results for compliance with performance requirements specified in "Field Quality Control" Article.

1.4.6 Water Samples and Reports: Specified in "Cleaning" Article.

1.5 Quality Assurance

1.5.1 ASME Compliance for Plastic Tanks: Fabricate and stamp plastic, pressure water storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section X, "Fiber-Reinforced Plastic Pressure Vessels."

1.5.2 NSF Compliance: NSF 14, "Plastics Piping Components and Related Materials," and NSF 61, "Drinking Water System Components--Health Effects." Include appropriate NSF marking.

PART 2 PRODUCTS

2.1 Performance Requirements

2.1.1 Pressure Rating of Pressure-Type Water Tanks: At least 860 kPa (125 psig), unless otherwise indicated.

2.1.2 Pressure Rating of Specialties and Accessories for Pressure Systems: At least 860 kPa (125 psig), unless otherwise indicated.

2.1.3 Pressure Rating of Piping for Pressure Systems: At least 860 kPa (125 psig), unless otherwise indicated.

2.1.4 Pressure Rating of Other Tanks and Piping Components: At least equal to system operating pressure.

2.2 GRP TANK (Sectional unit)

2.2.1 Supply and install where shown on Drawings, pressed moulded GRP sectional water tanks of the modular bolted sections type. Panels shall be of the insulated type with rigid polyurethane foam 25 mm thick and resin cover on top. Panels shall be at least 5 mm thick. The tank shall be internally reinforced by stainless steel tie rods and externally by galvanized structural steel. The panels shall be joined by galvanized steel nuts and bolts with a synthetic rubber sealant in between. Tank shall be covered totally and cover shall be strong enough to support maintenance staff. Nuts and bolts for flanges shall be of rubber capped galvanized steel.

2.2.2 Each tank shall have at least 400 mm concrete pedestal and shall be complete with:

- External and internal ladders made from UPVC or GRP.
- UPVC Air vent with COWL.
- Hinged inspection cover on top, with sealed lid overflow, and drain.
- Level indicators.

2.3 Accessories

2.3.1 Overflow: The overflow for the tank shall consist of an overflow weir and outside drop pipe, adequately supported. The overflow pipe shall be PVC and shall terminate 300 to 600 mm above grade and shall be fitted with a flapper valve or screen to prevent ingress of birds and insects.

2.3.2 Vent: Vent shall be tank manufacturer's standard type, factory supplied, mushroom vent with stainless bird screen. The free area of the vent shall be sized 50 percent in excess of the pump-in rate.

2.3.3 Float Valves: The float valves shall be full bore, equilibrium ball type, designed to close tight against maximum pressure when half submerged, with renewable, synthetic rubber, valve disc and balancing piston bucket. Float valves to be all bronze construction including levers and arms, with Stainless Steel float and suitable for 1034 kPa cold water working pressure.

2.3.4 Drain Valve: Bronze/Cast Iron non-rising stem with indicator, for minimum working pressure of 1034 kPa, clear waterway equal to full nominal diameter, hand wheel operated, and open by turning counterclockwise.

2.4 Concrete Low Level Water Reservoir(s)

2.4.1 The low level concrete Reservoir(s) shall be as shown on drawings and as described here or under another section of the Specifications.

2.4.2 The reservoir(s) shall be provided with float valves, having copper ball floats and bronze valves and rods.

2.4.3 The reservoir(s) shall be provided with level indicators and contacts for low level cut out of water pumps and contacts for low and high level alarms carried to a suitable panel preferably in the pump room or as instructed by the Engineer.

2.5 Concrete High Level Water Reservoir(s)

2.5.1 The roof water reservoir(s) shall be as shown on drawings and as described here or under another section of the Specifications.

2.5.2 The reservoir(s) shall be provided with a float switch, with two contacts for starting and stopping of the water pumps. A suitable control panel shall start the pumps upon demand from the roof reservoir and shall stop the pumps when the tank is full.

2.5.3 The reservoir(s) shall be provided with contacts for overflow and low level alarms carried to a suitable panel located where ever shown on the Drawings or as instructed by the Engineer.

PART 3 EXECUTION

3.1 Concrete Bases

3.1.1 Install concrete bases of dimensions indicated, or otherwise required, for water tanks. Refer to Division 3 Section "Cast-in-Place Concrete" and Division 15 Section "Basic Mechanical Materials and Methods."

3.2 Water Storage Tank Installation

3.2.1 Install water storage tanks on concrete bases, level and plumb, firmly anchored. Arrange so devices needing servicing are accessible.

3.2.1.1 Install horizontal tanks on concrete piers and factory-fabricated saddles.

3.2.1.2 Install horizontal tanks on fabricated steel supports and saddles.

3.2.2 Anchor tank supports and tanks to substrate. Install tank seismic restraints.

3.3 Connections

3.3.1 Install piping adjacent to water storage tanks to allow service and maintenance.

3.3.2 Install thermometers and pressure gages on water storage tanks and piping. Thermometers and pressure gages are specified in Division 15 Section "Meters and Gages."

3.3.3 Connect water piping to water storage tanks with unions or flanges and with shutoff valves. Connect tank drains with shutoff valves and discharge over closest floor drains.

3.3.3.1 General-duty valves are specified in Division 15 Section "Valves."

3.3.3.2 Valves DN50 (NPS 2) and Smaller: Gate or ball. (Bronze)

3.3.3.3 Valves DN65 (NPS *2-1/2)* and Larger: Gate or butterfly. (Cast Iron)

3.3.3.4 Drain Valves: DN20 (NPS *3/4)* gate or ball valve. Include outlet with, or nipple in outlet with, ASME B1.20.7, 3/4-11.5NH thread for garden-hose service, threaded cap, and chain.

3.3.4 Install the following devices on tanks:

3.3.4.1 Pressure relief valves.
3.3.4.2 Temperature-and-pressure relief valves.
3.3.4.3 Vacuum relief valves. Include on tanks with copper interior lining unless tank has no valve.
3.3.4.4 Tank vents on nonpressure tanks.
3.3.4.5 Connections to accessories.

3.4 Field Quality Control

3.4.1 Pressure Testing: Hydrostatically test ASME code, water storage tanks to ensure structural integrity and freedom from leaks. Fill tanks with water, vent air, pressurize to 1-1/2 times tank pressure rating, disconnect test equipment, hold pressure for 30 minutes with no drop in pressure, and check for leaks. Replace tanks that fail test with new tanks and repeat until test is satisfactory.

3.4.2 Pressure Testing: Hydrostatically test non-ASME code, pressure water storage tanks to ensure structural integrity and freedom from leaks at pressure of 345 kPa (50 psig) above system operating pressure, but not less than 1035 kPa (150 psig). Fill tanks with water, vent air, pressurize tanks, disconnect test equipment, hold pressure for two hours with no drop in pressure, and check for leaks. Repair or replace tanks that fail test with new tanks and repeat until test is satisfactory.

3.4.3 Nonpressure Testing: Fill nonpressure water storage tanks to water operating level to ensure structural integrity and freedom from leaks. Hold water level for two hours with no drop in water level.

3.4.4 Repair leaks and defects with new materials and retest system until results are satisfactory.

3.4.5 Prepare written reports for specified tests.

3.5 Cleaning

3.5.1 Clean and disinfect water storage tanks.

3.5.2 Use purging and disinfecting procedure prescribed by Engineer or, if method is not prescribed, use procedure described in AWWA C652 or as described below:

3.5.2.1 Purge water storage tanks with potable water.

3.5.2.2 Disinfect tanks by one of the following methods:

3.5.2.2.1 Fill tanks with water/chlorine solution containing at least 50 mg/L (50 ppm) of chlorine. Isolate tanks and allow to stand for 24 hours.

3.5.2.2.2 Fill tanks with water/chlorine solution containing at least 200 mg/L (200 ppm) of chlorine. Isolate tanks and allow to stand for three hours.

3.5.2.3 Flush tanks, after required standing time, with clean, potable water until chlorine is not present in water coming from tank.

3.5.2.4 Submit water samples in sterile bottles to Engineer. Repeat procedure if biological examination shows evidence of contamination.

3.5.3 Prepare written reports for purging and disinfecting activities.

3.6 Commissioning

3.6.1 Perform the following final checks before filling:

3.6.1.1 Verify that tests of tanks are complete.

3.6.1.2 Verify that tests of piping systems are complete.

3.6.1.3 Check piping connections for leaks.

3.6.1.4 Verify that pressure relief valves have correct setting.

3.6.1.5 Test operation of tank accessories and devices.

3.6.1.6 Manually operate relief valves.

3.6.1.7 Adjust pressure settings.

3.6.1.8 Manually operate vacuum relief valves.

3.6.1.9 Adjust vacuum settings.

3.6.1.10 Check for proper seismic restraints

3.6.2 Filling Procedures: Follow manufacturer's written procedures. Fill tanks with water to operating level.

END OF SECTION 22 12 00

SECTION 22 13 00
FACILITY SANITARY SEWAGE

SECTION 22 13 00
FACILITY SANITARY SEWERAGE

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Sanitary Drainage

1.1.1 The Sanitary 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.

1.1.2 Pipe installations shall not be concealed within the building structure un satisfactory completion of the inspection and testing procedure.

1.1.3 Traps shall conform to BS 5572 and all relevant British Standards.

1.1.4 Plastic traps shall be to BS 3943 and of 'P' type unless otherwise specified.

1.1.5 For sinks, showers, baths, bidets and bowl urinals, traps shall be a two piece tubular trap, and bottle trap for lavatory basin.

1.1.6 Floor drains subject to evaporation shall have a water seal of 125mm.

1.1.7 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.

1.2 Site Drainage

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

1.3 Reference Standard

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

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standards	Title of Standards

National Plumbing Code	NPC		-
Uniform Plumbing Code	UPC		-
British Standards	BS	BS497	Specifications for manhole covers, road gully gratings and frames for drainage purposes
		BS4164	Specification for coal tar-based hot-applied coating materials for protecting iron and steel, including a suitable primer
		BS8005 PART 1	Guide to new sewerage construction.

1.5 Related Works Specified Elsewhere

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

Section 22 05 00 - General Mechanical Requirements for Plumbing.
Section 22 07 00 - Plumbing Insulation
Section 22 12 00 - Facility Potable Water Storage Tanks
Section 22 14 00 - Facility Storm Drainage
Section 22 40 00 - Plumbing Fixtures
Section 22 90 00 - Pool and Fountain Plumbing System

PART 2 PRODUCTS

2.1 Gully Traps (PVC)

2.1.1 Each gully trap shall be of heavy duty UPVC construction and of the P or S-trap type.

2.1.2 Gully trap shall have either cast iron open grating cover or solid recessed cover with cast iron frame as shown on the Drawings and/or as need be.

2.2 PVC Floor Drains with Stainless Steel Cover

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

2.2.2 Each floor drain shall be of the UPVC construction with 70 mm water seal.

2.2.3 Drain shall have stainless steel AISI 304 removable square tile with circular grid strainer and stainless steel cover. 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.

2.2.4 Stainless steel covers shall have minimum 15 years warranty.

2.2.5 Tile shall fit, as practical as possible, one floor tile of the space.

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

2.2.7 This floor drain is applicable to bathrooms, toilets, kitchens and pantries.

2.2.8 Floor drain in Domestic Washing Machine Room shall be sealed type.

2.3 Cleanouts

2.3.1 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.

2.3.2 Floor pipe cleanouts on PVC pipes shall have stainless steel cover.

2.4 PVC Roof Vent Caps

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

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

2.5 Trench Grate & Frame

2.5.1 Ductile or Cast Iron

2.5.1.1 Grate shall be ductile or 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.

2.6 Frames, Covers & Gratings

2.6.1 All covers and frames shall be manufactured either from Cast iron to BS 497 Part I or Ductile iron manufactured to BSEN 124 as approved by Local Authority.

2.6.2 All castings for frames, covers, and gratings 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 epoxy coating complying with the requirements specified in BS 4164. Coating surfaces shall be clean, dry and free from rust before applying the coatings.

2.6.3 Covers of manholes located inside buildings shall be of double seal and those located outside shall be of single seal.

2.6.4 Covers of last manhole discharging to city sewer shall be integral with GRP sealing plate.

2.7 Bronze Floor Drains

2.7.1 Supply and install bronze floor drain in all mechanical rooms in hospital building and service building of sizes and shaped as indicated on the drawings.

2.7.2 Drain shall have Tundish (Funnel) to receive waste water from indirect waste lines and exposed grate surrounding Tundish to receive drain from surrounding floor area.

2.7.3 Each floor drain shall consist of cast bronze body, flashing collar with seepage opening and polished bronze adjustable strainer head with Tundish attached to the grate with concealed screws, permitting funnel to be moved to different positions on the grate. Tundish diameter shall be 100 mm.

2.8 PVC Floor Drains

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

2.8.2 Each floor drain shall be of the UPVC construction with 70 mm water seal.

2.8.3 Drain shall have white polypropylene 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.

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

2.8.5 This drain shall be applicable to shafts.

2.9 PVC Floor Drains with Sealed Type Stainless Steel Cover

2.9.1 Supply and install whenever down on the drawings floor drains of sizes and shapes or indicated on the drawings.

2.9.2 Each floor drain shall be of the UPVC construction with 70 mm water seal.

2.9.3 Drain shall have stainless steel AISI 304 removable square tile with stainless steel screw type circular access cover or with gasket and stainless steel screws.

2.9.4 Stainless steel covers shall have minimum 15 years warranty.

2.9.5 Drain shall be fitted with 1" (25 mm) access plug for cleaning purposes.
This floor drain is applicable for washing machine outlets.

2.10 Floor Drains

2.10.1 Supply and install where shown on drawings extra-heavy duty floor drains of sizes as indicated thereupon.

2.10.2 Each drain shall have square or round top, dura-coated cast iron body with p-trap and brass screwed access cap, cast iron raising piece (if need be), heavy duty grating and suspended sediment bucket.

PART 3 EXECUTION

3.1 Internal Drainage Installation Requirements

3.1.1 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.

3.1.2 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.

3.1.3 All plumbing fixtures shall be individually trapped and vented. Rough in and install fixtures at height as recommended by manufacturer unless otherwise indicated.

Sinks directly connected to grease traps shall not be trapped.

3.1.4 Vent piping shall not be trapped and shall be graded to drip back to waste or soil line.

3.1.5 Changes in direction of piping shall be generally made with long radius fittings.

3.1.6 Floor drains subject to evaporation shall have a water seal of 125mm.

3.1.7 Floor drains shall be clamped to flashing or to water proofing membrane. Clamping collars shall be supplied with drains only where flashing is required.

3.1.8 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.

3.1.9 All pipes and fittings shall be kept clean, with the exposed ends of in-completed or unconnected work to be plugged.

3.1.10 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.

3.1.11 All pipes running under building or under streets shall be encased in concrete of minimum100 mm thickness.

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

3.2 External. Drainage Installation Requirements

3.2.1 Connections to manholes shall be watertight after installation.

3.2.2 All piping shall conform accurately to the lines and grades shown on the Drawings.

3.2.3 Any connections for existing systems shall be made with a minimum amount of disturbance to the existing lines.

3.2.4 Any existing pipe lines or structures which are damaged while making connections shall be replaced or reconstructed to the satisfaction of the Engineer without cost to the Employer.

3.2.5 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.

3.2.6 System shall be inspected and joints approved before any backfilling is placed over pipes.

3.2.7 All pipe and fittings shall be kept clean until final acceptance of work. The exposed ends of all in-completed lines shall be closed with wooden plugs adequately secured at all times when pipe laying is not actually in progress.

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

3.2.9 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.

3.3 Manholes Installation Requirements

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

3.3.2 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.

3.3.3 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.

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

3.3.5 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.

3.3.6 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.

3.4 Trench Bottom Grading

3.4.1 All Trench Bottom Grading Required For Plumbing Work Shall Be Done Under The Requirements Of This Section Of The Specification. 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.

3.4.2 After The Pipe Lines Have Been Tested And Approved, Backfill Shall Be Compacted Thoroughly By Hand Tampers Below Center Lines Of Pipes And To At Least 300mm 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, 20mm Crushed Stone Or Gravel Above The Top Of Piping And Hubs.

3.5 Frames, Covers & Gratings

3.5.1 The Contractor shall furnish and set level and to the proper grade, 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 to BS 497 Part 1.

3.5.2 All castings for frames, covers, and gratings shall be of tough gray iron, complying with BS

2789: 1973 (Updated 1985). 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 based material complying with the requirements specified in BS 4164. Coating surfaces shall be clean, dry and free from rust before applying the coatings.

3.5.3 Covers of manholes located inside buildings shall be of double seal and those located outside shall be of single seal.

3.6 Excavation and Backfilling for Pipe Laying

3.6.1 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.

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

3.6.3 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.

3.6.4 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. 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.

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

3.6.6 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.

3.7 Drainage Testing

3.7.1 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.

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

3.7.3 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.

3.8 Fixtures Testing

3.8.1 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 as per tests sections. Any defects shall be corrected, at the expense of the Contractor.

3.8.2 After all fixtures are connected, the entire system shall be subjected to a smoke test. For PVC piping the correct grade of cartridge should be selected so that it is not harmful to the pipe-work or joint materials or an air test shall be performed in accordance with BS B005 Part 1.

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

End of Section 22 13 00.

SECTION 22 13 16
SANITARY WASTE AND VENT PIPING

SECTION 22 13 16

SANITARY WASTE AND VENT PIPING

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Introduction

1.1.1 Works of this Section shall be governed by Conditions of Contract and requirements.

1.1.2 This section describes basic materials and requirements for Pipe work services installations for building.

1.2 Related Works Specified Elsewhere

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

Section 22 0500 - General Mechanical Requirements for Plumbing.
Section 22 0700 - Plumbing Insulation
Section 22 13 00 - Facility Sanitary Sewerage
Section 22 14 00 - Facility Storm Drainage
Section 22 40 00 - Plumbing Fixtures

1.3 Storage of UPVC Pipes

1.3.1 UPVC 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 1.5 m. (or as recommended by the manufacturer) with sockets at alternate ends, and in such a manner as to prevent sagging or bending.

1.4 Pipe Identification

1.4.1 All pipes shall be indelibly marked at intervals of not greater than 3m. The marking shall show the manufacturer's identification, the standard name and number, and the nominal size and class. Adhesive labels alone shall not suffice. All pipes complying with British Standards shall be kite marked.

1.5 Codes and Standards

1.5.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
American Water Works Association	AWWA	C601-68 C501-67 M45	FIBERGLASS PIPE DESIGN MANUAL
American Society for Testing and Materials	ASTM	ASTM A53-88a	Specification for pipes, steel, black and Hot-Dipped, Zinc-Coated, Welded and Seamless
		ASTM A307	Specification for Carbon Steel Bolts and Studs. 60,000 psi tensile Strength
		ASTM D1785	Specification for poly (vinyl chloride) (PVC) plastic pipe schedules 40, 80, and 120.
		ASTM D3517M	Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermo-Setting-Resin) Pressure Pipe.
American Standards Association	ASA	ASA 40.1	-
		ASA B16.22	-
		ASA B1618	-
		ASA B9.1	-
		ASA B35.5	-
British Standards	BS	BS 4514	Specification for unplasticized PVC soil and venting pipes, fittings and accessories.
		BS 5255	Specification for thermoplastics waste pipe and fittings.
		BS 5254	Specification for polypropylene waste pipe and fittings (external diameter 34.6 mm, 41.0 mm and 54.1 mm)
		BS 3505	Specification for unplasticized polyvinyl chloride (PVC-U) pressure pipes for cold potable water

		BS 4346 Part 1	Joints and fittings for use with unplasticized PVC pressure pipes. Injection molded un plasticized PVC fittings for solvent welding for use with pressure pipes, including potable water supply.
		BS4346 Part 2	Mechanic joints and fittings, principally of unplasticized PVC.
		BS 4660	Specification for unplasticized polyvinyl chloride (PVC-U) pipes and plastics fittings of nominal sizes 110 and 160 for below ground gravity, drainage, and Sewerage
		BS 5480	Specification for Glass Reinforced Plastic (GRP) Pipes, Joints and Fittings for use of Water Supply or Sewerage.
		BS 5481	Specification for unplasticized PVC pipe and fittings for gravity sewers
		BS 1387	Specification for screwed and socketed steel tubes and tubular and for plain and steel tube suitable for welding or for screwing to BS21 p
		BS 3601	Specification for carbon steel pipes and tubes with specified room temperature properties for pressure pipes.
		BS 21	Specification for pipe threads for tubes and fittings where pressure light joints are made on the threads.
Deutches Institute for Normung	DIN	DIN 19534	-
American National Standards Institute	ANSI	ANSI B18.2.2	
		ANSI B31.1	
		ANSI A21, 10, 11	-

PART 2 PRODUCTS

2.1 UPVC Pipes TYPE 1

2.1.1 Polyvinyl chloride pipes (PVC) shall be of the unplasticized rigid type and of high density and complete homogeneity material

2.1.2 UPVC Pipes - Type 1 shall comply with BS EN 1329-1 : 2000 specification for pipes, fittings and the system.

2.1.3 UPVC Pipes - Type 1 piping systems shall be used in the field of:

2.1.3.1 Soil and waste discharge systems (low and high temperature) inside buildings (marked with "B").

2.1.3.2 Soil and waste discharge systems for both inside buildings and buried in ground within the building structure (marked with "BD").

2.1.3.3 Ventilation pipe work.

2.1.4 UPVC Pipes Type 1 piping system sockets and spigots shall be either tor solvent cement joints or ring seal joints.

2.2 UPVC Pipes - Type 3

2.2.1 Polyvinyl chloride pipes (PVC) shall be of the un-plasticized rigid type and of high density and complete homogeneity material.

2.2.2 UPVC Pipes - Type 3 shall comply with BS EN 1401-1 : 1998 specifications for pipes, fittings and the system.

2.2.3 UPVC Pipes - Type 3 shall be used in the field of non-pressure under ground drainage and sewerage:

2.2.3.1 Outside the building structure (marked "U") and

2.2.3.2 Both buried in ground within the building structure and outside the building (marked "0").

2.3 High Density Polyethylene Pipes (HDPE)

2.3.1 HDPE pipes shall be made from polyethylene (PE) as per ISO 4427: 1996 (E) Standard.

2.3.2 HDPE pipes shall be manufactured from polyethylene type PE 100 resin, it shall contain only those antioxidants, UV stabilizers and pigments necessary for the manufacture of pipes confirming to ISO 4427 specifications.

2.3.3 Pressure rating for HDPE pipes shall be SDR 11 (pn 16), nominal outside diameter and the wall thickness shall conform to ISO 161-1:1996.

2.3.4 Fittings shall be electro fusion type for pipe up to 4" (100 mm) dia. and butt fusion for pipes above 4" (100 mm) dia.

2.3.5 HDPE pipes shall be allowed to be used for drainage pipes buried in raft.

2.4 Piping Schedule

2.4.1 <u>General</u>

2.4.1.1 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:

2.4.2 <u>Piping Classes</u>

Service	Piping Class
Drainage and vent pipes above ground	PVC Type 1
Sanitary sewer under building structure	PVC Type 3
Sanitary sewer running in raft slab	HDPE

PART 3 EXECUTION

3.1 Arrangement and Alignment of Pipes

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

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

3.1.3 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 ½" (15 mm) drain gate valves shall be supplied and installed at all low points and riser legs.

3.2 **Special Requirement for PVC Pipe Installation**

3.2.1 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.

3.2.2 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 relay 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.

3.2.3 Plumbing vents exposed to sun light shall be protected by water base synthetic latex paints.

3.2.4 Thermal Expansions

3.2.4.1 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:

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

3.2.6 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.

3.2.7 .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.

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

3.2.9 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.

3.3 **General Requirements for Piping Installation**

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

3.3.2 Make all branch connections with tees.

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

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

3.3.5 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.

3.3.6 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.

3.3.7 Pipes and fittings shall both be manufactured according to one single standard unit of measurement in metric.

3.4 Pipe Sleeves

3.4.1 Provide all pipe openings through walls, partitions and slabs with sleeves having an internal diameter at least 50mm larger than the outside diameter of the pipe for un- insulated lines or of the insulation for insulated pipes.

3.4.2 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.

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

3.4.4 Sleeve construction:

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

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

3.5 **Cleaning of Piping Systems**

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

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

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

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

3.5.5 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.

3.5.6 During the disinfecting period, care shall be exercised to prevent contamination of water in steel main.

3.6 Material Tests and Identification

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

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

3.7 Testing

3.7.1 <u>Drainage and Sewer Pipes</u>

3.7.1.1 Drains and sewers should generally be subjected to an internal pressure test of 1.2 m head of water above the crown of the pipe at the high end but not more than 6 m at the low end Inspection and tests should be made during the installation and as the work proceeds, to ensure the pipe work is properly secured and clear of obstructing debris and superfluous matter.

3.7.1.2 The final test of the completed drainage and vent system shall be made by filling all traps with water and then introducing into the entire system a pungent, thick smoke produced by one or more smoke machines. When the smoke appears at stack openings on the roof, the stack openings shall be closed and a pressure equivalent to a 1-inch water column (248.8 Pa) shall be held for a test period of not less than 15 minutes.

End of Section 22 13 16.

SECTION 22 1400

FACILITY STORM DRAINAGE

SECTION 22 14 00

FACILITY STORM DRAINAGE

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Storm Drainage

1.1.1 Storm water shall be drained by means of roof drains and leaders and free discharged around the building at convenient locations shown on the Drawings.

1.2 Reference Standard

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

1.3 Codes and Standards

1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable standard	Title of Standard
National Plumbing Code	NPC		-
Uniform Plumbing Code	UPC		-
British Standards	BS	BS497	Specification for manhole covers, road gully gratings and frames for drainage purposes.
		BS4164	Specification for coal tar-based hot-applied coating materials for protecting iron and steel. Including a suitable primer.
		BS8005 Part 1	Guide to new sewerage construction.

1.4 Related Works Specified Elsewhere

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

Section 22 05 00 - General Mechanical Requirements for Plumbing.

Section 22 13 00 - Facility Sanitary Sewerage
Section 22 1429 - Sump Pumps
Section 22 3000 - Plumbing Equipment

PART 2 PRODUCTS

2.1 UPVC Pipes Type 1

2.1.1 Polyvinyl chloride pipes (PVC) shall be of the unplasticized rigid type and of high density and complete homogeneity material

2.1.2 UPVC Pipes - Type 1 shall comply with BS EN 1329-1 : 2000 specification for pipes, fittings and the system.

2.1.3 UPVC Pipes - Type 1 piping systems shall be used in the field of:

2.1.3.1 Ventilation pipe work.

2.1.3.2 Rainwater pipe work within the building structure.

2.1.4 UPVC Pipes Type 1 piping system sockets and spigots shall be either for solvent cement joints or ring seal joints.

2.2 UPVC Pipes - Type 3

2.2.1 Polyvinyl chloride pipes (PVC) shall be of the un-plasticized rigid type and of high density and complete homogeneity material.

2.2.2 UPVC Pipes - Type 3 shall comply with BS EN 1401-1 : 1998 specifications for pipes, fittings and the system.

2.2.3 UPVC Pipes - Type 3 shall be used in the field of non-pressure underground storm.

2.2.3.1 Outside the building structure (marked "U") and

2.2.3.2 Both buried in ground within the building structure and outside the building (marked "0").

2.3 PVC Roof and Balcony Drains

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

2.3.2 Balcony drains shall have flat type UPVC strainer.

2.3.3 Angled / Corner roof drain. This drain shall be of Robust UPVC Body and Grate.

2.4 Cleanouts

2.4.1 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.

2.4.2 Floor pipe cleanouts on PVC pipes shall have stainless steel cover.

PART 3 EXECUTION

3.1 3.1 Internal Storm Water Installation Requirements

3.1.1 All storm drainage piping above grade shall have a slope of two percent (2%) where possible the minimum acceptable is one percent (1%).

3.1.2 Changes in direction of piping shall be generally made with long radius fittings.

3.1.3 All pipes and fittings shall be kept clean, with the exposed ends of in-completed or unconnected work to be plugged.

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

3.1.5 All pipes running under building or under streets shall be encased in concrete of minimum 100 mm thickness.

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

3.2 Testing

3.2.1 If an inspection of the completed 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.

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

3.2.3 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.

End of Section 22 1400.

SECTION 22 14 29

SUMP PUMPS

SECTION 22 14 29

SUMP PUMPS

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Pump Selection & Design Requirements

1.1.1 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 pump selections and the shop drawings are approved.

1.1.2 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.

1.1.3 Construct all apparatus of materials and pressure ratings suitable for the conditions encountered during continuous operation.

1.1.4 Provide shaft packing or seals compatible with the pump design, and in accordance with the manufacturer's recommendations.

1.1.5 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.

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

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

1.2 Related Works Specified Elsewhere

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

Section 22 0500 - General Mechanical Requirements for Plumbing.
Section 22 0700 - Plumbing Insulation
Section 22 1300 - Facility Sanitary Sewerage
Section 22 1400 - Facility Storm Drainage
Section 22 3 000 - Plumbing Equipment
Section 224000 - Plumbing Fixtures
Section 22 50 00 - Pool and Fountain Equipment

1.3 Pumping Equipment Operating Characteristics

1.3.1 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.

1.3.2 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.

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

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

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

1.3.6 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. Motor should be sized to have minimum 20% extra as safety margin on the total power requirements.

PART 2 PRODUCTS

2.1 **Submersible Sump Pumps**

2.1.1 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.

2.1.2 Pumps shall have duty/assist function and there shall be a level switch for this function which is additional to duty/standby function.

2.1.3 The pump/motor housing shall be complete with:

2.1.3.1 Lifting Yoke.

2.1.3.2 Electrical terminal board, and submersible electric flexible cable between pump motor and control unit.

2.1.3.3 Ball bearings good for three years continuous operation.

2.1.3.4 Stainless steel shaft with precision ground finish.

2.1.3.5 Stator, cast iron stator housing and class F stator insulation.

2.1.3.6 Rotor.

2.1.3.7 Statically and dynamically balanced non-clog impeller with a flow passage cross-section of (65mm) for sewage application.

2.1.3.8 Cast iron pump housing.

2.1.3.9 Base(and Strainer for waste water application.)

2.1.3.10 Tungsten carbide shaft seals to withstand heavily contaminated liquid.

2.1.3.11 Gate valve and check valve at pump discharge.

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

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

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

2.1.4.3 Discharge connection with lower guide rail bracket.

2.1.4.4 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.

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

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

2.1.7 The control unit shall be complete with circuit breakers, earth leakage sensor with alarm annunciation as required by the authorities starters, automatic electric alternator, indicating lights and lockable type hand-off-auto selector switches and volt free contacts for connection to BMS.

PART 3 EXECUTION

3.1 Installation of Pumps

3.1.1 Pumps shall be mounted on bases with isolating pads as specified in the specification.

3.1.2 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.

3.1.3 Pumps shall be secured to bases with proper size anchor bolts.

3.1.4 Drains for packing glands and base shall be piped to nearest drain outlet.

3.1.5 Where corrosion can occur, appropriate corrosion-resistant materials and assembly methods must be used including isolation of dissimilar metals against galvanic interaction.

3.1.6 Provide casing connections for vents, drains, suction and discharge pressure gauges.

3.1.7 Balance impellers and all other moving components statically and dynamically.

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

3.1.9 Install packing rings with alternate layers staggered 90 degrees. Tighten packing for seal while permitting prescribed amount of leakage.

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

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

3.1.12 Coupling guards shall be provided to all pumps.

3.2 Pump Settings

3.2.1 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.

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

3.2.3 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.

3.3 Pumps Testing

3.3.1 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.

3.3.2 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.

3.3.3 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.

3.3.3.1 Water flow, GPM (I/s) at rated head. Shut-off head.

3.3.3.2 Operating Kilowatts from measured voltage, amperes and power factor.

3.4 Spare Parts

3.4.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

3.5 Special Tools

3.5.1 A complete set of special tools, oil and grease for all the plant and equipments supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

3.6 Operation and Maintenance Manuals

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

3.6.1.1 Brief description of each system and its service and basic operation features.

3.6.1.2 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.

3.6.1.3 Maintenance instructions for each type of equipment.

3.6.1.4 Possible breakdowns and repairs for each type of equipment.

3.6.1.5 List of nearest local suppliers for all equipment.

3.6.1.6 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.

3.6.1.7 Complete, as installed, color coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

3.6.1.8 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

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

3.7 Guarantee and Warrantee Period

3.7.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.

3.7.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.

3.7.3 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 substantial completion certificate.

End of Section 22 1429.

SECTION 22 40 00

SANITARY FIXTURES

SECTION 22 40 00

SANITARY FIXTURES

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract and it's requirements.

1.1 Scope of Work

1.1.1 The Sanitary Fixtures along with accessories, pipe fittings shall be installed and put in operation as hereinafter specified and as shown on drawings.

1.1.2 All fixtures and trimmings, insofar as practicable, shall be of one manufacture.

1.1.3 Ample application of petroleum jelly shall be made to all surfaces of exposed chrome plated piping, valves and fittings immediately after installation.

1.1.4 All fixtures shall be set straight and true.

1.1.5 Concealed brackets, hangers and plates shall have a shop coat of paint.

1.1.6 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.

1.1.7 Contractor shall comply with authorities requirements for Green Building (if applicable) and shall consider the following flow rates:-

1.1.7.1 Maximum flow rate for shower = 1.5 gpm
1.1.7.2 Maximum flow rate for Lavatory = 0.5 gpm
1.1.7.3 Maximum flow rate for all toilets = 1.1 gallon per flush
1.1.7.4 All Toilets shall be dual flush.
1.1.7.5 All ablutions taps shall be self closing type.

1.2 Related Works Specified Elsewhere

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

Section 22 05 00 - General Mechanical Requirements for Plumbing
Section 22 10 00 - Plumbing Piping and Pumps
Section 22 30 00 - Plumbing Equipment

PART 2 PRODUCTS

2.1 Sanitary Fixtures

2.1.1 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.

2.1.2 Vitreous china fixtures shall be of first quality with smooth glazed surfaces, free from warp, cracks, checks, discolorations or other imperfections.

2.1.3 Enameled cast iron fixtures shall be of acid-resisting type.

2.1.4 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 do 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.

2.1.5 All fixtures and fittings types and models shall be as detailed in the schedule of fixtures, indicated on the Drawings.

2.2 Accessories

2.2.1 Accessories shall be provided in the locations indicated on Architectural Drawings and fixed at heights indicated therein or as directed by the Engineer. The Accessories shall be from approved manufacturers.

PART 3 EXECUTION

3.1 Exposed Piping and Trim in Toilet Areas

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

3.2 Fixture Setting

3.2.1 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.

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

3.3 Cleaning

3.3.1 On a daily basis as the Works of this Section proceed, remove and dispose of all debris resulting from the Works of this Section.

3.3.2 Leave work areas of the Works of this Section broom clean at the end of each work day.

End of Section 22 40 00

SECTION 230500

COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

PART 2 EXECUTION

SECTION 23 05 00
COMMON WORK RESULTS FOR HVAC

PART 1 GENERAL

1.1 GeneralRequirements

1.1.1 The work of this Section shall be governed by General Conditions of Contract.

1.1.2 It is the Contractors responsibility to be fully aware of and comply with all of the requirements of the above listed documents, and further assure that all Subcontractors are equally informed.

1.1.3 It is the Contractor's responsibility to be fully aware of and comply with all of the requirements of the district cooling provider in case the project is served by district cooling system.

1.2 Application

1.2.1 This section applies to and is part of all Sections of Division 23.

1.3 Scope of Works

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

- Requirements of fire dampers wherever duct crossing fire wall.
- System air balancing and associated requirements to do the balancing
- Maintaining the noise levels as specified
- Steel platforms (flyover) above services in plant rooms and roof.
- Chemical dosing and flushing of chilled water system to the satisfaction of the Engineer.

1.3.2 Unless specifically mentioned otherwise, the following electrical works and materials for the Mechanical equipment shall be supplied and installed under Division 23 of the specification but in all respect to the requirements of the Electrical Specifications.

a- All control panels including door lock disconnected switches, push buttons, starters, contractors, circuit breakers, time delays, selector switches, relays, transformers, timers, controllers, pilot lights, set points, alarms 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.

b- Whenever a number of starters controllers, instruments, indicating lights and the like occur or are shown on the Mechanical and/or electrical Drawings, 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, bus bars, starters, instruments, relays, push-buttons, indicating lights and the like. Components shall be mounted in a logical order based on the sequence of operation.

c- All control equipment including thermostats, sensors, detectors, actuators, controllers, pressure level and flow switches, annunciation alarms, remote control stations and all such equipment needed for the proper system operation.

d- All control wiring for the above mentioned equipment.

e- Final connection, between disconnect switches, power outlets, flex outlet and mechanical equipment.

f- The following electrical works and materials for the mechanical equipment shall be supplied and installed under the electrical part of this contract.

i. Allpower supply uptoandincluding thefollowing:

·Power outlets forfancoil units.
·Disconnect switches when specified to be installed separate from the control panel.
·Flexoutlet forexhaust fans.

ii. Power supply up to control panels when specified with an integral disconnect switch
iii. Power supply to disconnect switches when the switches are built-in the equipment.
iv. Empty conduits with pull wires for all cables and wires classified under the mechanical scope of works.

v. Control outlet boxes for all control equipment classified under the mechanical scope of works.

vi. Power cables and conduits or fixing arrangement between chilled water pumps, air handling units, etc..and their control panel.

vii. Power cables and conduits from central control panel to the various equipment controlled from the same panel, such as exhaust fans, supply air fans, etc..

1.4 Quality Assurance

1.4.1 The manufacturer's of all materials and equipment must have at least ten years of experience in the design and manufacture of their products.

1.5 Related Work Specified Else Where

1.5.1 In addition to the mentioned above, the works shown herein after shall be applicable along with the requirements of the related divisions and sections.

1.6 Engineer's Drawings

1.6.1 The Drawings are based on design 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 head room, and to keep openings and passage ways clear without additional instruction and without additional cost to the owner.

1.7 Shop Drawings and Data to be Submitted for Approval

1.7.1 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. Shop Drawings scale shall be*1/10, 1/20, 1/50* and *1/100* as applicable and as approved by the Engineer.

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

1.7.3 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. Inaddition the Contractor shall submit manufacturer's printed installation instructions.

1.7.4 The Contractor shall submit at the beginning of the project a schedule of submittals for materials and shop drawings to the approval of the Engineer.

1.8 Approved Materials

1.8.1 All materials shall be furnished in accordance with the requirements of the Specifications. The naming of manufacturers in the Specifications shall be strictly adhered to in all circumstances.

1.8.2 Substitution of materials other than those named shall not be submitted.

1.8.3 Materials shall be delivered in unbroken packages bearing the brand and maker's name, and shall be stored on platforms and properly covered toprotect them from moisture, heat and dust.

1.8.4 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.

1.9 Instruction Period

1.9.1 The Contractor shall be responsible for the training and familiarization of the Employer's maintenance staff for a period of at least six weeks on all equipment and plants he has supplied or installed.

1.10 Machinery Guards

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

1.10.2 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.

1.11 Instruction Manual and As-built Drawings

1.11.1 The Contractor shall furnish and submit to the Engineer in electronic and hard copy triplicate bound, A4size, Instruction Manuals containing the following material:

1.11.2 Brief description of each system and its service and basic operation features.

1.11.3 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 listshall include manufacturer's recommended spare parts for one year operation.

1.11.4 Chart of the tag numbers, location and function of each

valve.

1.11.5 Maintenance instructions for each type of equipment.

1.11.6 Possible break downs and repairs for each type of

equipment.

1.11.7 List of nearest local suppliers for all equipment.

1.11.8 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.

1.11.9 Complete, as installed, color coded wing diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

1.11.10 The Contractor shall furnish all the fore going to the Engineer for his review as to the fulfillment of the specified requirements.

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

1.12 Abbreviations

1.12.1 The following abbreviations have been mentioned in the specifications.

1.12.1.1	AMCA	-Air Moving and Conditioning Associations.
1.12.1.2	ANSI	-American National Standard Institute.
1.12.1.3	ARI	-Ai r Conditioning and Refrigeration Institute.
1.12.1.4	ASA	-Acoustical Society of America, American Standards Association.
1.12.1.5	ASHRAE	-American Society of Heating Refrigeration and Air Conditioning Engineers
1.12.1.6	ASME	-American Society of Mechanical Engineers.
1.12.1.7	ASTM	-American Society for Testing and Materials.
1.12.1.8	BSI	-British Standards Institution
1.12.1.9	SMACNA	-Sheet Metal and Air Conditioning Contractors National Association
1.12.1.10	UL	-Under Writers Laboratories.
1.12.1.11	BTU	-British Thermal Units.

1.13 Workmanship

1.13.1 All workmanship required to accomplish the work mentioned in Mechanical specification or shown on related Drawings, shall conform to the highest standards, and as required by the Engineer.

1.13.2 The Engineer will be the sale judge of the standards required.

PART 2 EXECUTION

2.1 Cleaning and Adjusting

2.1.1 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 here in specified.

2.2 Tests

2.2.1 All piping and equipment shall be tested as specified under the corresponding section of the Specifications and to meet local and specified 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.

2.2.2 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.

2.2.3 Ingeneral, 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.

2.2.4 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.

2.2.5 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.

2.2.6 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.

2.2.7 The following tests should be furnished for but limited to the following:

a- Vibration isolation test
b- Sound attenuator test
c- Insulation test
d- Chilled water pipe tests
e- Chiller Test
f- Refrigeration plant test.
g- Pump tests
h- Air handling unit tests
i- Fan coil unit tests
j- Air and water balancing
k- Exhaust systems tests
l- Noise and vibration measurement
m- Room condition tests
n- Controls and building management test

2.3 Coordination ofTrades

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

2.4 Access Doors

2.4.1 Access doors shall provide ready access to concealed control valves, traps, cleanouts, motors, firedampers, andother items requiring operation, adjustment, ormaintenance.

2.4.2 Doors and frames shall be of 12-gauge galvanized steel with invisible hinges, and cam lockfastenings. Forplaster walls orceiling, frames shall have a50mm. wide lath plaster bond. Formasonry walls, theframe shall besetflush with masonry with provisions inthe jamb for anchoring. Doors shall besolid flush steel with grey metal primer. Location of access doors shall becoordinated withandshall havetheapproval oftheEngineer before themechanical work isinstalled.

2.5 Permits

2.5.1 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.

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

2.6 Openings inExterior Walls

2.6.1 Openings in exterior walls, particularly at or below grade shall be kept properly plugged and caulked at all times, (except when being worked on) to preclude 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.

End of Section 23 05 00.

SECTION 23 05 29

HANGERS AND SUPPORTS FOR HVAC PIPING

PART 1 GENERAL

SECTION 230529

HANGERSAND SUPPORTS FOR HVAC PIPING

PART 1GENERAL

Works of this Section shall be governed by Conditions of Contract.

1.1 Hangers and Supports, Anchors and Guides -General

1.1.1 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.

1.1.2 Fasten piping securely to the structure without over stressing 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.

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

1.1.4 Un-insulated copper or brass pipe and/or tubing shall be isolated from ferrous hangers or supports

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

1.1.6 Clearance for application of specified Vapour sealed insulation without cutting pipe line covering or fitting covering in installation of pipe hangers and fittings shall be provided.

1.1.7 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 andcontract.

1.1.8 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.

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

1.1.10 Provide trapeze hangers where several pipes can be installed parallel and atthe 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.

1.1.11 For hanger rods on piping 3/8"(10mm) thru2"(50mm) inclusive use3/8" (10mm)rods, and for piping 2 ½"(65 mm) thru 5" (125 mm) use 5/8" (16 mm) rods, and for piping6"(150 mm)thru 12"(300mm) use7/8"(22mm) rods.

1.1.12 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.

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

1.1.14 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.

1.1.15 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 to1500Ibs(680 Kg)maximum loading provide welded steel bracket.

1.1.16 Pipe-covering (insulation) protection saddles.

1.1.17 Provide hanger shields to protect vapor sealed pipe insulation within mechanical equipment rooms at each support point by a 360 degree insert of high density, 100 psi, water proofed calcium silicate encased in a120o 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 discernable deformation. Insert shall extend 25mm. beyond sheet metal shield. 100mm. shields shall be26 gauge minimum. Shields 130 to 230mm. long shall be20gauge minimum. Shields longer than 230mm. shall be16gauge.

1.1.18 Provide penetration shields to encase insulated pipes penetrating firewalls or floors in a 360 o24gauge minimum sheet metal hanger shield with insert of high density, 100psi. water proofed calcium silicate the same thickness as 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 asbestos rope. Install an escutcheon plate to completely cover the wall penetration opening and fitsnugly over the pipe insulation shield. Insert shall extend at least 25mm. Beyond penetrated surface and escutcheon.

1.1.19 Provide oversize hangers with blocking the same thickness as the insulation to pitch vapor sealed insulated pipes accurately attimeofinsulation.

1.2 Horizontal Piping Support Schedule

1.2.1 Steel, Copper andPVCPipes

- ¾"and 1"(20and25mm) steel pipe-----2.5 meter
- 1½"-2" (32and50mm) steel pipe-------3.0 meter
- 2½"-4" (65and 100mm)steel pipe------4.0 meter
- 5"-6"(125and150mm) steel pipe---------5.0 meter
- 8"(200 mm)and above steel pipe---------6.0 meter
- Upto1½" (32mm) copper pipe----------2 ..0meter
- 1¼"(40mm)and over copper pipe------3.0 meter
- 2½"(65mm)and smaller PVC pipe-------1.2 meter
- 3" (80 mm)and over PVC pipe-------------1.8 meter

End of Section 23 05 29.

SECTION 230593

TESTING, ADJUSTING AND BALANCING FOR HVAC

PART 1 General

1.1 Related Documents

1.1.1 Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division D1 Specification Sections, apply to this Section.

1.2 Summary

1.2.1 A qualified and approved third party shall carry out and certify the commissioning, testing, adjusting and balancing of the installed systems as per the relevant commissioning code of the British Chartered Institute of Building Services (CIBS) or ASHRAE Standards.

1.2.2 Major equipment such as chillers, cooling towers, fresh air units, chilled water pumps and heat exchangers shall be tested and commissioned at factory and contractor shall arrange for the Client Representative and consultant to witness this test at factory.

1.2.3 Testing, adjusting and balancing for all the installed systems shall include chilled water distribution, air distribution, noise and vibration measurement, automatic controls as per the procedure herein after.

1.2.4 The Contractor shall be responsible to provide during installation all necessary provisions to carry out the above works as required by the third party.

1.2.5 All costs shall be paid by the Contractor.

1.3 General Requirements

1.3.1 All piping and equipment shall be tested as specified under the relevant subsection of the specification.

1.3.2 Labour, materials, instruments, power etc., required for testing shall be furnished by the contractor unless otherwise indicated under the particular section of the Specification

1.3.3 Test shall be performed in the presence of representatives of the Engineer and such other parties as may have legal jurisdiction.

1.3.4 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.

1.3.5 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.

1.3.6 Any damages resulting from tests shall be repaired and/or damaged materials replaced, all to the satisfaction of the Engineer, and at no

1.3.7 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

1.3.8 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.

1.3.9 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.

1.3.10 Three copies of all test results shall be submitted to the Engineer.

1.4 Submittals

1.4.1 Two copies of Testing, Adjusting and Air Balancing strategies plans to be submitted. Plans should show step-by-step procedures as specified in Part 3. Include also a complete set of report forms intended for use on this Project.

1.4.2 Submit two copies of reports prepared, as specified in this Section, on approved forms certified by Testing, Adjusting and Air Balancing firm. Warranties if specified in this Section.

1.5 Quality Assurance

1.5.1 Ensure the participation of Testing, Adjusting and Air Balancing team members, equipment manufacturers' authorized service representatives, HVAC controls installers, and other support personnel. Provide notice in advance of scheduled meeting time and location.

1.5.2 Coordinate the efforts of factory-authorized service representatives for systems and equipment, HVAC controls installers, and other mechanics to operate HVAC systems and equipment to support and assist Testing, Adjusting and Air Balancing activities.

1.5.3 Certify Testing, Adjusting and Air Balancing field data reports by reviewing field data reports to validate accuracy of data, and certify that Testing, Adjusting and Air Balancing team complied with approved Testing, Adjusting and Air Balancing plan and the procedures specified and referenced in this Specification.

1.5.4 Use approved standard forms.

1.5.5 Calibrate instruments at least every six months or more frequently as required by instrument manufacturer.

1.5.1.1 Keep an updated record of instrument calibration that indicates date of calibration and the name of party performing instrument calibration.

1.6 Project Conditions

1.7.1 Completed areas of the project might be occupied during Testing, Adjusting and Balancing or before Substantial Completion. Cooperate with Owner during Testing, Adjusting and Balancing operations to minimize conflicts with Client's operations.

1.7 Warranty

1.7.2 Provide a guarantee on National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems" forms stating that-

1.7.3 The certified Testing, Adjusting and Balancing firm has tested and balanced systems according to the Contract Documents.

1.7.4 Systems are balanced to optimum performance capabilities within design and installation limits.

PART 2 PRODUCTS

NOT APPLICABLE

PART 3 EXECUTION

3.1 Examination

3.1.1 Examine the Contract Documents to become familiar with Project requirements and to address conditions in systems' designs that may preclude proper Testing, Adjusting and Balancing of systems and equipment.

3.1.1.1 Contract Documents are defined in the General and Supplementary Conditions of Contract.

3.1.1.2 Verify that balancing devices, such as test ports, gage cocks, thermometer wells, flow control devices, balancing valves and fittings, and manual volume dampers, are required by the Contract Documents. Verify that quantities and locations of these balancing devices are accessible and appropriate for effective balancing and for efficient system and equipment operation.

3.1.2 Examine approved submittal data of HVAC systems and equipment.

3.1.3 Examine Project Record Documents described in Division 01 Section "Project Record Documents."

3.1.4 Examine design data, including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.

3.1.5 Examine equipment performance data including fan and pump curves. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from those presented when the equipment was performance tested at the factory. To calculate system effects for air systems, use tables and charts found in AMCA 201, "Fans and Systems," Sections 7 through 10; or in SMACNA's "HVAC Systems--Duct Design," Sections 5 and 6. Compare this data with the design data and installed conditions.

3.1.6 Examine system and equipment installations to verify that they are complete and that testing, cleaning, adjusting, and commissioning specified in individual Sections have been performed.

3.1.7 Examine system and equipment test reports.

3.1.8 Examine HVAC system and equipment installations to verify that indicated balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, and manual volume dampers, are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation.

3.1.9 Examine systems for functional deficiencies that cannot be corrected by adjusting and balancing.

3.1.10 Examine HVAC equipment to ensure that clean filters have been installed, bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.

3.1.11 Examine terminal units, such as variable-air-volume boxes, to verify that they are accessible and their controls are connected and functioning.

3.1.12 Examine plenum ceilings used for supply air to verify that they are airtight. Verify that pipe penetrations and other holes are sealed.

3.1.13 Examine strainers for clean screens and proper perforations.

3.1.14 Examine heat-transfer coils for correct piping connections and for clean and straight fins.

3.1.15 Examine system pumps to ensure absence of entrained air in the suction piping.

3.1.16 Examine equipment for installation and for properly operating safety interlocks and controls.

3.1.17 Examine automatic temperature system components to verify the following:

3.1.17.1 Dampers, valves, and other controlled devices are operated by the intended controller.

3.1.17.2 Dampers and valves are in the position indicated by the controller.

3.1.17.3 Integrity of valves and dampers for free and full operation and for tightness of fully closed and fully open positions. This includes dampers in multizone units, mixing boxes, and variable-air -volume terminals.

3.1.17.4 Automatic modulating and shutoff valves, including two-way valves and three-way mixing and diverting valves, are properly connected.

3.1.17.5 Thermostats and humidistats are located without adverse effects of sunlight, drafts, and cold walls.

3.1.17.6 Sensors are located to sense only the intended conditions.

3.1.17.7 Sequence of operation for control modes is according to the Contract Documents.

3.1.17.8 Controller set points are set at indicated values.

3.1.17.9 Interlocked systems are operating.

3.1.18 Report deficiencies discovered before and during performance of Testing, Adjusting and Balancing procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 Preparation

3.2.1 Prepare a Testing, Adjusting and Balancing plan that includes strategies and step-by-step procedures.

3.2.2 Complete system readiness checks and prepare system readiness reports. Verify the following :

3.2.2.1 Permanent electrical power wiring is complete. Hydronic

3.2.2.2 systems are filled, clean, and free of air. Automatic

3.2.2.3 temperature-control systems are operational. Equipment

3.2.2.4 and duct access doors are securely closed. Balance,

3.2.2.5 smoke, and fire dampers are open.

3.2.2.6 Isolating and balancing valves are open and control valves are operational.

3.2.2.7 Ceilings are installed in critical areas where air-pattern adjustments are required and access to balancing devices is provided.

3.2.2.8 Windows and doors can be closed so indicated conditions for system operations can be met

3.3 Testing and Balancing Producers

3.3.1 Testing Air Balancing General Procedure

3.3.1.1 Perform testing and balancing procedures on each system according to the procedures shown herein after.

3.3.1.2 Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary to allow adequate performance of procedures. After testing and balancing, close probe holes and patch insulation with new materials identical to those removed. Restore vapor barrier and finish according to insulation Specifications for this Project.

3.3.1.3 Mark equipment and balancing device settings with paint or other suitable, permanent identification material, including damper-control positions, valve position indicators, fan- speed control levers, and similar controls and devices, to show final settings.

3.3.1.4 Take and report testing and balancing measurements in inch-pound (IP) and metric (SI) units

3.3.1.5 Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Crosscheck the summation of required outlet volumes with required fan volumes.

3.3.1.6 Prepare schematic diagrams of systems' "as-built" duct layouts.

3.3.1.7 Develop a plan to simulate diversity for variable-air-volume systems.

3.3.1.8 Determine the best locations in main and branch ducts for accurate duct airflow measurements.

3.3.1.9 Check airflow patterns from the outside-air louvers and dampers and the return- and exhaust-air dampers, through the supply-fan discharge and mixing dampers.

3.3.1.10 Locate start-stop and disconnect switches, electrical interlocks, and motor starters.

3.3.1.11 Verify that motor starters are equipped with properly sized thermal protection.

3.3.1.12 Check dampers for proper position to achieve desired airflow path.

3.3.1.13 Check for airflow blockages.

3.3.1.14 Check condensate drains for proper connections and functioning.

3.3.1.15 Check for proper sealing of air-handling unit components.

3.3.1.16 Check for proper sealing of air duct system.

3.3.1.17 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

3.3.2 <u>Procedures for Constant-Volume Air Systems</u>

3.3.2.1 Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

3.3.2.1.1 Measure fan static pressures to determine actual static pressure as follows:-

a.]Measure outlet static pressure as far downstream from the fan as practicable and upstream from restrictions in ducts such as elbows and transitions.

b. Measure static pressure directly at the fan outlet or through the flexible connection.

c. Measure inlet static pressure of single-inlet fans in the inlet duct as near the fan as possible, upstream from flexible connection and downstream from duct restrictions.

d. Measure inlet static pressure of double-inlet fans through the wall of the plenum that houses the fan.

3.3.2.1.2 Measure static pressure across each component that makes up an air-handling unit, rooftop unit, and other air-handling and -treating equipment.

a. Simulate dirty filter operation and record the point at which maintenance personnel must change filters.

3.3.2.1.3 Measure static pressures entering and leaving other devices such as sound traps, heat recovery equipment, and air washers, under final balanced conditions.

3.3.2.1.4 Compare design data with installed conditions to determine variations in design static pressures versus actual static pressures. Compare actual system effect factors with calculated system effect factors to identify where variations occur. Recommend corrective action to align design and actual conditions.

3.3.2.1.5 Obtain approval from Engineer for adjustment of fan speed higher or lower than indicated speed. Make required adjustments to pulley sizes, motor sizes, and electrical connections to accommodate fan-speed changes.

3.3.2.1.6 Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan- motoramperage to ensure that no overload will occur. Measure amperage in full cooling, full heating, economizer, and any other operating modes to determine the maximum required brake horsepower.

3.3.2.2 Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows within specified tolerances.

3.3.2.2.1 Measure static pressure at a point downstream from the balancing damper and adjust volume dampers until the proper static pressure is achieved. Where sufficient space in submain and branch ducts is unavailable for Pitot-tube traverse measurements, measure airflow at terminal outlets and inlets and calculate the total airflow for that zone.

3.3.2.2.2 Remeasure each submain and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.

3.3.2.3 Measure terminal outlets and inlets without making adjustments.

3.3.2.3.1 Measure terminal outlets using a direct-reading hood or outlet manufacturer's written instructions and calculating factors.

3.3.2.4 3.3 .2.4 Adjust terminal outlets and inlets for each space to indicated airflows within specified tolerances of indicated values .. Make adjustments using volume dampers rather than extractors and the dampers at air terminals.

3.3.2.4.1 Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.

3.3.2.4.2 Adjust patterns of adjustable outlets for proper distribution without drafts.

3.3.3 <u>Procedures for Variable-Air-Volume Systems</u>

3.3.3.1 Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a maximum set- point airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

3.3.3.2 Pressure-Independent, Variable-Air-Volume Systems: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

3.3.3.2.1 Set outside-air dampers at minimum, and return- and exhaust-air dampers at a position that simulates full-cooling load.

3.3.3.2.2 Select the terminal unit that is most critical to the supply-fan airflow and static pressure.

3.3.3.2.3 Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.

3.3.3.2.4 Measure total system airflow. Adjust to within indicated airflow.

3.3.3.2.5 Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal-unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

3.3.3.2.6 Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.

3.3.3.2.7 Remeasure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.3.3.2.8 Measure static pressure at the most critical terminal unit and adjust the static-pressure controller at the main supply-air sensing station to ensure that adequate static pressure is maintained at the most critical unit.

3.3.3.2.9 Record the final fan performance data.

3.3.3.3 Pressure-Dependent, Variable-Air-Volume Systems without Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

3.3.3.3.1 Balance systems similar to constant-volume air systems.

3.3.3.3.2 Set terminal units and supply fan at full-airflow condition.

3.3.3.3.3 Adjust inlet dampers of each terminal unit to indicated airflow and verify operation of the static-pressure controller. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

3.3.3.3.4 Readjust fan airflow for final maximum readings.

3.3.3.3.5 Measure operating static pressure at the sensor that controls the supply fan, if one is installed, and verify operation of the static-pressure controller.

3.3.3.3.6 Set supply fan at minimum airflow if minimum airflow is indicated. Measure static pressure to verify that it is being maintained by the controller.

3.3.3.3.7 Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow as described for constant-volume air systems. If air outlets are out of balance at minimum airflow, report the condition but leave the outlets balanced for maximum airflow.

3.3.3.3.8 Measure the return airflow to the fan while operati.ng at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.3.3.4 Pressure-Dependent, Variable-Air-Volume Systems with Diversity: After the fan systems have been adjusted, adjust the variable-air-volume systems as follows:

3.3.3.4.1 Set system at maximum indicated airflow by setting the required number of terminal units at minimum airflow. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.

3.3.3.4.2 Adjust supply fan to maximum indicated airflow with the variable-airflow controller set at maximum airflow.

3.3.3.4.3 Set terminal units at full-airflow condition.

3.3.3.4.4 Adjust terminal units starting at the supply-fan end of the system and continuing progressively to the end of the system. Adjust inlet dampers of each terminal unit to indicated airflow. When total airflow is correct, balance the air outlets downstream from terminal units as described for constant-volume air systems.

3.3.3.4.5 Adjust terminal units for minimum airflow.

3.3.3.4.6 Measure static pressure at the sensor.

3.3.3.4.7 Measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return-air ducts and inlets as described for constant-volume air systems.

3.3.4 <u>Procedures for Motors</u>

3.3.4.1 Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:

3.3.4.1.1 Manufacturer, model, and serial numbers.

3.3.4.1.2 Motor horsepower rating.

3.3.4.1.3 Motor rpm.

3.3.4.1.4 Efficiency rating.

3.3.4.1.5 Nameplate and measured voltage, each phase.

3.3.4.1.6 Nameplate and measured amperage, each phase.

3.3.4.1.7 Starter thermal-protection-element rating.

3.3.4.2 Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass for the controller to prove proper operation. Record observations, including controller manufacturer, model and serial numbers, and nameplate data.

3.3.5 <u>Procedures For Condensing Units</u>

3.3.5.1 Verify proper rotation of fans.

3.3.5.2 Measure entering- and leaving-air temperatures.

3.3.5.3 Record compressor data.

3.3.6 <u>Procedures for Temperature Measurements</u>

3.3.6.1 During TAB, report the need for adjustment in temperature regulation within the automatic temperature-control system.

3.3.6.2 Measure indoor wet- and dry-bulb temperatures every other hour for a period of two successive eight-hour days, in each separately controlled zone, to prove correctness of final temperature settings. Measure when the building or zone is occupied.

3.3.6.3 Measure outside-air, wet- and dry-bulb temperatures.

3.3.7 Procedures for Space Pressurization Measurements and Adjustments

3.3.7.1 Before testing for space pressurization, observe the space to verify the integrity of the space boundaries. Verify that windows and doors are closed and applicable safing, gaskets, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

3.3.7.2 Measure, adjust, and record the pressurization of each room, each zone, and each building by adjusting the supply, return, and exhaust airflows to achieve the indicated conditions.

3.3.7.3 Measure space pressure differential where pressure is used as the design criteria, and measure airflow differential where differential airflow is used as the design criteria for space pressurization.

3.3.7.3.1 For pressure measurements, measure and record the pressure difference between the intended spaces at the door with all doors in the space closed. Record the high-pressure side, low-pressure side, and pressure difference between each adjacent space.

3.3.7.3.2 For applications with cascading levels of space pressurization, begin in the most critical space and work to the least critical space.

3.3.7.3.3 Test room pressurization first, then zones, and finish with building pressurization.

3.3.7.4 To achieve indicated pressurization, set the supply airflow to the indicated conditions and adjust the exhaust and return airflow to achieve the indicated pressure or airflow difference.

3.3.7.5 For spaces with pressurization being monitored and controlled automatically, observe and adjust the controls to achieve the desired set point.

3.3.7.5.1 Compare the values of the measurements taken to the measured values of the control system instruments and report findings.

3.3.7.5.2 Check the repeatability of the controls by successive tests designed to temporarily alter the ability to achieve space pressurization. Test over-pressurization and under pressurization, and observe and report on the system's ability to revert to the set point.

3.3.7.5.3 For spaces served by variable-air-volume supply and exhaust systems, measure space pressurization at indicated airflow and minimum airflow conditions.

3.3.7.6 In spaces that employ multiple modes of operation, such as normal mode and emergency mode or occupied mode and unoccupied mode, measure, adjust, and record data for each operating mode.

3.3.7.7 Record indicated conditions and corresponding initial and final measurements. Report deficiencies.

3.3.8 Procedures for Vibration Measurements

3.3.8.1 Use a vibration meter meeting the following criteria:

3.3.8.1.1 Solid-state circuitry with a piezoelectric accelerometer.

3.3.8.1.2 Velocity range of 0.1 to 10 inches per second (2.5 to 254 *mm/s).* Displacement range of 1 to 100 mils (0.0254 to 2.54 mm). Frequency range of at least 0 to 1000 Hz.

3.3.8.1.3 Capable of filtering unwanted frequencies.

3.3.8.2 Calibrate the vibration meter before each day of testing.

3.3.8.2.1 Use a calibrator provided with the vibration meter.

3.3.8.2.2 Follow vibration meter and calibrator manufacturer's calibration procedures.

3.3.8.3 Perform vibration measurements when other building and outdoor vibration sources are at a minimum level and will not influence measurements of equipment being tested.

3.3.8.3.1 Turn off equipment in the building that might interfere with testing.

3.3.8.3.2 Clear the space of people.

3.3.8.4 Perform vibration measurements after air and water balancing and equipment testing is complete.

3.3.8.5 Clean equipment surfaces in contact with the vibration transducer.

3.3.8.6 Position the vibration transducer according to manufacturer's written instructions and to avoid interference with the operation of the equipment being tested.

3.3.8.7 Measure and record vibration on rotating equipment over 3 hp (2.2 kW).

3.3.8.8 Measure and record equipment vibration, bearing vibration, equipment base vibration, and building structure vibration. Record velocity and displacement readings in the horizontal, vertical, and axial planes.

3.3.8.8.1 Fans and HVAC Equipment with Fans:

a. Fan Bearing: Drive end and opposite end.
b. Motor Bearing: Drive end and opposite end.
c. Equipment Casing: Top and side.
d. Equipment Base: Top and side.
e. Building Floor.
f. Ductwork: To and from equipment after flexible connections.
g. Piping: To and from equipment after flexible connections.

3.3.8.8.2 HVAC Equipment with Compressors:

a. Compressor Bearing: Drive end and opposite end.
b. Motor Bearing: Drive end and opposite end.
c. Equipment Casing: Top and side.
d. Equipment Base: Top and side.
e. Building: Floor.
f. Piping: To and from equipment after flexible connections

3.3.8.9 For equipment with vibration isolation, take floor measurements with the vibration isolation blocked solid to the floor and with the vibration isolation floating. Calculate and report the differences.

3.3.8.10 Inspect, measure, and record vibration isolation.

3.3.8.10.1 Verify that vibration isolation is installed in the required locations.

3.3.8.10.2 Verify that installation is level and plumb.

3.3.8.10.3 Verify that isolators are properly anchored.

3.3.8.10.4 For spring isolators, measure the compressed spring height, the spring OD, and the travel to-solid distance.

3.3.8.10.5 Measure the operating clearance between each inertia base and the floor or concrete base below. Verify that there is unobstructed clearance between the bottom of the inertia base and the floor.

3.3.9 <u>Procedures for Sound-Level Measurements</u>

3.3.9.1 Perform sound-pressure-level measurements with an octave-band analyzer complying with ANSI S1.4 for Type 1 sound-level meters and ANSI S1.11 for octave-band filters. Comply with requirements in ANSI S1.13, unless otherwise indicated.

3.3.9.2 Calibrate sound meters before each day of testing. Use a calibrator provided with the sound meter complying with ANSI S1.40 and that has NIST certification.

3.3.9.3 Use a microphone that is suitable for the type of sound levels measured. For areas where air velocities exceed 100 fpm (0.51 *m/s),* use a windscreen on the microphone.

3.3.9.4 Perform sound-level testing after air and water balancing and equipment testing are complete.

3.3.9.5 Close windows and doors to the space.

3.3.9.6 Perform measurements when the space is not occupied and when the occupant noise level from other spaces in the building and outside are at a minimum.

3.3.9.7 Clear the space of temporary sound sources so unrelated disturbances will not be measured. Position testing personnel during measurements to achieve a direct line-of- sight between the sound source and the sound-level meter.

3.3.9.8 Take sound measurements at a height approximately 48 inches (1200 mm) above the floor and at least 36 inches (900 mm) from a wall, column, and other large surface capable of altering the measurements.

3.3.9.9 Take sound measurements in dBA and in each of the 8 unweighted octave bands in the frequency range of 63 to 8000 Hz.

3.3.9.10 Take sound measurements with the HVAC systems off to establish the background sound levels and take sound measurements with the HVAC systems operating.

3.3.9.10.1 Calculate the difference between measurements. Apply a correction factor depending on the difference and adjust measurements.

3.3.10 Procedures for Stair-Case Pressurization System Measurements and Adjustments

3.3.10.1 Before testing, observe the stair tower to verify that construction is complete. Verify the following:

3.3.10.1.1 Walls and ceiling are free of unintended openings and are capable of achieving a pressure boundary.

3.3.10.1.2 Fire stopping and sealants are installed.

3.3.10.1.3 Doors, door closers, and door gaskets are installed and adjusted.

3.3.10.1.4 If applicable, window installation is complete.

3.3.10.2 Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

3.3.10.3 Test each stair tower as a single system. If multiple fans serve a single stair tower, operate the fans together.

3.3.10.4 Air Balance:

3.3. 10.4.1 Open the doors indicated to be open and measure, adjust, and record the airflow of each:

a. Stair-tower fan.
b. Air outlet supplying the stair tower.

3.3. 10.4.2 For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

3.3.10.5 Pressurization Test

3.3.10.5.1 After air balancing is complete, perform stair-tower pressurization tests.

3.3.10.5.2 Establish a consistent procedure for recording data throughout the entire test. Set the stair-tower side of the doors as the reference point and the floor side of the doors with positive pressure when higher than the stair tower, and negative pressure when lower than the stair tower.

3.3.10.5.3 With the HVAC systems operating in their normal mode of operation and the stair-tower pressurization systems off, measure and record the following:

a. Pressure difference across each stair-tower door with all doors in the stairwell closed.

b. Force necessary to open each door, using a spring-type scale.

3.3.10.5.4 With the HVAC systems operating and the stair-tower pressurization system activated, perform the following:

a. Place building HVAC systems in their normal operating mode .including equipment not used to implement smoke control, such as air-handling units, toilet exhaust fans, fan coil units, and similar equipment.

b. Measure and record the pressure difference across each stair-tower door with all doors in the stair tower closed. Adjust the stair-tower pressure relief to prevent over pressurization.

c. Use a spring scale to measure and record the force needed to open the door closest to the fan. With the initial door held in the open position, measure and record the pressure difference across each remaining closed stair-tower door.

d. Open additional doors (up to the number indicated) one at a time, and measure and record the pressure difference across each remaining closed stair-tower door after the opening of each additional door.

e. Open the doors indicated to be open and measure and record the direction and velocity through each of the open doors by a traverse of every 1 sq. ft. (0.093-sq. m) grid of door opening.

f. Calculate the average of the door velocity measurements. Compare the average velocity to the Contract Documents and governing code requirements.

3.3.10.5.5 Repeat the pressurization tests with the smoke-control systems and the HVAC systems operating.

3.3.10.5.6 Criteria for Acceptance:

a. The opening force on any door shall not exceed 30 Ibf (133 N).
b. Code requirements.

3.3.10.6 Operational Tests:

3.3.10.6.1 Check the proper activation of the stair-tower pressurization system(s) in response to all means of activation, both automatic and manual.

3.3.10.6.2 Verify that each initiating occurrence produces the proper system response under each of the following modes of operation:

a. Normal.
b. Alarm.
c. Manual override of normal mode and alarm.
d. Return to normal.

3.3.10.6.3 Verify that the smoke detector at the stair pressurization fan inlet de-energizes the fan and closes the damper at the fan.

3.3.10.6.4 If standby power is provided for stair pressurization systems, test to verify that the stair pressurization systems operate while on both normal and standby power.

3.3.10.6.5 Conduct additional tests required by authorities having jurisdiction.

3.3.10.7 Prepare a complete report of observations, measurements, and deficiencies.

3.3.11 <u>Procedures for Smoke-Control System Testing</u>

3.3.11.1 Before testing smoke-control systems, verify that construction is complete and verify the integrity of each smoke-control zone boundary. Verify that windows and doors are closed and that applicable safing, gasket, and sealants are installed. Report deficiencies and postpone testing until after the reported deficiencies are corrected.

3.3.11.2 Measure and record wind speed and direction, outside-air temperature, and relative humidity on each test day.

3.3.11.3 Measure, adjust, and record airflow of each smoke-control system with all fans that are a part of the system operating as intended by the design.

3.3.11.4 Measure, adjust, and record the airflow of each fan. For ducted systems, measure the fan airflow by duct Pitot-tube traverse.

3.3.11.5 After air balancing is complete, perform the following pressurization testing for each smoke control zone in the system:

3.3.11.5.1 Verify the boundaries of each smoke-control zone.

3.3.11.5.2 With the HVAC systems in their normal mode of operation and smoke control not operating, measure and record the pressure difference across each smoke-control zone. Make measurements after closing doors that separate the zones. Make one measurement across each door. Clearly indicate the high and low pressure side of each door.

3.3.11.5.3 With the system operating in the smoke-control mode and with each zone in the smoke control system activated, perform the following:

a. Measure and record the pressure difference across each door that separates the smoke zone from adjacent zones. Make measurements with doors that separate the smoke zone from the other zones closed. Clearly indicate the high and low pressure side of the door. Doors that have a tendency to open slightly due to the pressure difference should have one pressure measurement made while held closed and another measurement made with the door open.

b. Continue to activate each separate zoned smoke-control system and make pressure difference measurements.

c. After testing a smoke zone's smoke-control system, deactivate the HVAC systems involved and return them to their normal operating mode before activating another zone's smoke-control system.

d. Verify that controls necessary to prevent excessive pressure differences are functional.

3.3.11.6 Operational Tests:

3.3.11.6.1 Check the proper activation of each zoned smoke-control system in response to all means of activation, both automatic and manual.

3.3.11.6.2 Check automatic activation in response to fire alarm signals received from the building's fire alarm and detection system. Initiate a separate alarm for each means of activation to ensure that the proper operation of the correct zoned smoke-control system occurs.

3.3.11.6.3 Check and record the proper operation of fans, dampers, and related equipment as outlined below for each separate zone of the smoke-control system.

a. Fire zone in which a smoke-control system automatically activates.

b. Type of signal that activates a smoke-control system, such as pull station, sprinkler water flow, or smoke detector.

c. Smoke zone(s) where maximum mechanical exhaust to the outside is implemented and no supply air is provided.

d. Positive pressure smoke-control zone(s) where maximum air supply is implemented and no exhaust to the outside is provided.

e. Fan(s) "ON" as required to implement the smoke-control system. Multiple- or variable-speed fans should be further noted as "MAX. VOLUME" to verify that the intended control configuration is achieved.

f. Fan(s) "OFF" as required to implement the smoke-control system.
g. Damper(s) "OPEN" where maximum airflow must be achieved.
h. Damper(s) "CLOSED" where no airflow should take place.

i. Auxiliary functions to achieve the smoke-control system configuration such as changes or override of normal operating pressure and temperature-control set points.

j. If standby power is provided for the smoke-control system, test to verify that the system functions while operating under both normal and standby power.

3.3.11.7 Conduct additional tests required by authorities having jurisdiction. Unless required by authorities having jurisdiction, perform testing without the use of smoke or products that simulate smoke.

3.3.11.8 Prepare a complete report of observations, measurements, and deficiencies.

3.3.12 <u>Procedures for Indoor-Air Quality Measurements</u>

3.3.12.1 After air balancing is complete and with HVAC systems operating at indicated conditions, perform indoor-air quality testing.

3.3.12.2 Observe and record the following conditions for each HVAC system:

3.3.12.2.1 3.3.12.2.1 The distance between the outside-air intake and the closest exhaust fan discharge, cooling tower, flue termination, or vent termination.

3.3.12.2.2 Specified filters are installed. Check for leakage around filters.

3.3.12.2.3 Cooling coil drain pans have a positive slope to drain.

3.3.12.2.4 Cooling coil condensate drain trap maintains an air seal.

3.3.12.2.5 Evidence of water damage.

3.3.12.2.6 Insulation in contact with the supply, return, and outside air is dry and clean.

3.3.12.3 Measure and record indoor conditions served by each HVAC system. Make measurements at multiple locations served by the system if required to satisfy the following:

3.3.12.3.1 Most remote area.

3.3.12.3.2 One location per floor.

3.3.12.3.3 One location for every 5000 sq. ft. (500 sq. m).

3.3.12.4 Measure and record the following indoor conditions for each location two times at two- hour intervals, and in accordance with ASHRAE 113:

3.3.12.4.1 Temperature. Relative humidity. Air velocity.

3.3.12.4.2 Concentration of carbon dioxide (ppm).

3.3.12.4.3 Concentration of carbon monoxide (ppm). Nitrogen oxides (ppm).

3.3.12.4.4 Formaldehyde (ppm).

3.3.13 <u>Procedures for Reliability Trial Test</u>

3.3.13.1 After finishing the above tests and adjustments, the Contractor shall be responsible for running a reliability trial test for the whole plant installed.

3.3.13.2 The whole of the trial of the Cooling Plant shall take place during the period between the 15th June and 15th September, and 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.

3.3.13.3 The trial shall last for a period of 15 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.

3.3.13.4 During the reliability trial test, performance tests shall be conducted on the Refrigerating Plant, the Heating Plant and the air handling equipment.

3.3.13.5 The test data shall not deviate by more than three percent (3%) from the guaranteed capacity data.

3.3.13.6 Temperature readings shall be taken for the entering and leaving air of each air handling unit.

3.3.13.7 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.

3.3.13.8 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.

3.3.14 <u>Procedures for Testing. Adjusting. And Balancing Existing Systems</u>

3.3.14.1 Perform a preconstruction inspection of existing equipment that is to remain and be reused.

3.3.14.1.1 Measure and record the operating speed, airflow, and static pressure of each fan.

3.3.14.1.2 Measure motor voltage and amperage. Compare the values to motor nameplate information.

3.3.14.1.3 Check the refrigerant charge.

3.3.14.1.4 Check the condition of filters.

3.3.14.1.5 Check the condition of coils.

3.3.14.1.6 Check the operation of the drain pan and condensate drain trap.

3.3.14.1.7 Check bearings and other lubricated parts for proper lubrication.

3.3.14.1.8 Report on the operating condition of the equipment and the results of the measurements taken. Report deficiencies.

3.3.14.2 Before performing testing and balancing of existing systems, inspect existing equipment that is to remain and be reused to verify that existing equipment has been cleaned and refurbished.

3.3.14.2.1 New filters are installed.

3.3.14.2.2 Coils are clean and fins combed.

3.3.14.2.3 Drain pans are clean.

3.3.14.2.4 Fans are clean ..

3.3.14.2.5 Bearings and other parts are properly lubricated.

3.3.14.2.6 Deficiencies noted in the preconstruction report are corrected.

3.3.14.3 Perform testing and balancing of existing systems to the extent that existing systems are affected by the renovation work ..

3.3.14.3.1 Compare the indicated airflow of the renovated work to the measured fan airflows and determine the new fan, speed, filter, and coil face velocity.

3.3.14.3.2 Verify that the indicated airflows of the renovated work result in filter and coil face velocities and fan speeds that are with.in the acceptable limits defined by equipment manufacturer.

3.3.14.3.3 If calculations increase or decrease the airflow and water flow rates by more than 5 percent, make equipment adjustments to achieve the calculated airflow and water flow rates. If 5 percent or less, equipment adjustments are not required.

3.3.15 <u>Air balance each air outlet. Procedures for Acceptance Tests</u>

3.3.15.1 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.

3.3.15.2 The date of commencement of the above said tests shall be subject to agreement with the

3.3.15.3 Engineer.

3.3.15.4 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.

3.4 Guarantee and Warranted Period

3.4.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.

3.4.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.

3.4.3 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 substantial completion certificate.

3.5 Maintenance During Defects Liability Period And Guarantees

3.5.1 Starting from the date of issue of the Substantial/Provisional completion certificate the contractor shall be responsible, for the duration of one year, to provide the following services free of charge, at his own cost-

3.5.2 The training of operators assigned by the client for operation of all major equipment and controls as decided by the Engineer.

3.5.3 Training should be provided by original suppliers of equipment for a period of at least one week and or when requested by Client throughout the liability period.

3.5.4 The replacement of parts or whole equipment that show any manufacturing or installation defects during operation.

3.5.5 Carry out routine preventive maintenance (fortnightly, monthly, quarterly, half yearly and yearly as applicable to the approval of the Engineer) including provision of labour, parts and supply of consumable materials such as Replaceable air filters, Chemicals for Chilled Water System, Chemicals for Swimming Pool, Lubricants and Refrigerant Gas, required for the safe operation and guarantee of performance of all the systems but not limited to;

a. VRF System
b. Pumps,
c. AHUs, FCUs,
d. Fans,
e. BMS

3.5.6 Necessary staff to carry out the above shall be provided to the job site during the said year.

3.5.7 On call emergency services (24 hours), particularly for elevators, escalators, revelators and fire alarm system.

3.5.8 Guarantee of every piece of equipment from any manufacturing or installation defects for a period of one year.

3.5.9 At the end of defects liability period the contractor shall be responsible for final handing over of all installed systems in a perfect condition to the satisfaction of both Engineer and client.

3.6 Extended Defects Liability and Guarantees

3.6.1 The Contractor shall issue a letter of guarantee for every compressor installed under his contract for a period of five years, starting from the date of issue of the completion certificate. Contractor shall remove the defective compressor and install a new one at his own expense including all necessary accessories and shall do the necessary testing and commissioning. Contractor shall submit a report to the Engineer explaining the reason of damage and methods to prevent it from happening.

3.6.2 The Contractor shall issue in favour of the client all original manufacturers extended guarantees as required by specifications or by Engineers approval conditions or by manufacturers initial proposal prior to final handing over to the client.

3.7 Maintenance and Guarantee

3.7.1 The Contractor shall submit along with his quotation a separate price for the maintenance of all of the Air Conditioning and plumbing works. The price shall be good for two consecutive years after the end of the maintenance period.

3.7.2 The price shall cover, but shall not be limited to the following items:

3.7.2.1 Yearly Maintenance

3.7.2.1.1 At the end of each year all equipment shall be serviced (checked and repaired), i.e... compressors, motors, pumps, heaters fans, etc.

3.7.2.2 Weekly Inspection

3.7.2.2.1 Competent technical representatives of the Contractor shall make weekly inspections to the plant and record the following readings on special log sheets:

3.7.2.2.2 Discharge and suction pressure and oil pressure of each packaged unit.

3.7.2.2.3 Power consumption (Amps) of each compressor, condenser fan, pump motor, heater, .etc.

3.7.2.2.4 Any inconsistency in the above readings or non compliance with manufacturers data shall be looked into by the Contractor; and after the cause is identified, he shall rectify and report it to the client. In the weekly inspection, the Contractor should make sure that the (AlC) design conditions inside the spaces are maintained and to the satisfaction of the occupants and that no machine or equipment is creating excessive noise.

3.7.2.3 Monthly Inspection

3.7.2.3.1 The Contractor's representative shall make the following monthly inspections:

3.7.2.3.1.1 Check and clean air filters of air handlers, fan coil units, fresh air grilles, etc ..

3.7.2.3.1.2 Check insulation of A/C pipes, ducts and check evidence of any condensation & do the necessary repairs.

3.7.2.3.1.3 Clean drain pans and drain pipes of all air handlers and fan coil units.

3.7.2.3.1.4 Check, adjust, and calibrate control system of air handlers and fan coil units.

3.7.2.3.1.5 Check and tighten belts of all fans.

3.7.2.3.1.6 Check the compressor's oil and refrigerant gas quantities and maintain always the required quantity.

3.7.2.4 Spare Parts

3.7.2.4.1 Contractor shall immediately replace any damaged or faulty item; spare parts should be always available. Parts shall be replaced at the cost of the Contractor.

3.7.2.5 Exclusions

3.7.2.5.1 Contractor shall submit a list of exclusions (if any) to the above, which he thinks are not part of his responsibilities or duties.

3.7.2.6 Contractor's Attendance

3.7.2.6.1 The Contractor is expected to respond to all requests from owner or owner's representative or owner's consultant to attend to the faults within 24 hours from the time he is called upon. He shall carry the necessary service as per the terms of the maintenance contract.

3.7.2.7 Guarantees

3.7.2.7.1 The contractor shall give the following guarantees for the following equipment whereby he shall immediately replace the same whenever found defective.

- Compressors 5 years
- Pump motors 5 years
- Condenser fins. 15 years
- Evaporators 15 years
- Air Handlers motors 5 years
- Air Handler casing against any rust, or corrosion or discoloration 10 years

End of Section 23 05 93.

SECTION 23 07 00

HVAC INSULATION

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

SECTION 230700

HVAC INSULATION

PART 1 GENERAL

Works of this Section shall be governed by Conditions of Contract.

1.1 ScopeofWork

1.1.1 Supply and install allinsulation and lagging onpiping, vessels orducts asindicated onthe drawings or specified to be insulated.

1.1.2 All insulation material shall have Zero Ozone Depletion Potential (ODP=O) and less than Five Global Warming Potential (GWP <5)..

1.1.3 Canvas jacket and all insulating materials shall benon-combustible, orself-extinguishing non-flame spread grade.

1.1.4 Insulation inexposed areas, i.e. permanently visible, shall be protected with aluminium cladding asspecified herein after.

1.2 RelatedWorksSpecified Elsewhere

1.2.1 All items specified inthis section are included ineach offollowing divisions, sections and sub-sections asapplicable, asifrepeated therein verbatim.

Section 230500 -Common Works Results forHVAC
Section 230900 -Instrumentation andControls forHVAC
Section 232000 -HVAC Piping and Pumps
Section 233000 -HVAC Air Distribution
Section 2340 00 -Air Cleaning Devices
Section 235000 -Central Heating Equipment
Section 236000 -Central Cooling Equipment
Section 237000 -Central HVAC Equipment
Section 238000 -Decentralized HVAC Equipment

1.3 Schedule of Insulation Thickness

1.3.1 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)
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- A/C condensate drain pipes	-	-	½(13)
- Supply and return air ducts	In conditioned spaces	-	1½ (38)
- Ditto	In unconditioned spaces	-	2 (50)
- Untreated fresh air duct	Passing through air plenum	-	1 (25)

- Refrigerant suction and liquid lines	-	-	¾ (20)

1.4 Codes and Standards

1.4.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
National Fire Protection Association	NFPA	NFPA90A	Standard for Air Conditioning and Ventilating Systems.
		NFPA90B	Standard for warm Air Heating and Air Conditioning Systems.
American Society for Testing and Materials	ASTM	ASTME96	Test method for water vapor transmission of materials

PART 2 PRODUCTS

2.1 Duct Insulation

2.1.1 Duct insulation in air-conditioned spaces shall be blankets of fibrous glass with a density of not less than 1.5Ib/ft3 (24 kg/m3) and aK-factor of not more than 0.26 Btu-in/ft2 hr. deg. F(0.038 W/m deg. K) at a mean temperature of75deg. F(24deg C) for concealed insulation.

2.1.2 Duct insulation in an air-conditioned spaces, mechanical rooms, and shafts shall be rigid board of fiber glass with areas in binder and a density of not less than 4*Ib/ft3* (64 kg/m2) and a K-factor of not more than 0.25 Btu-ln/ft2. hr. of (0.036 W/m $_{o}$ K) at a mean temperature of75^{o}F(24^{o}C) for outdoor application.

2.1.3 For cold air application, insulation shall be faced with factory applied reinforced foil and paper which comprises aluminum foil reinforced with fiber glass yarn mesh and laminated to 40Ibs chemically treated fire retardant Kraft.

2.1.4 50x50x0.6mm galvanized sheet metal angles shall be attached at corners.

2.2 PipeInsulation-TypeB

2.2.1 This type of insulation shall apply to Refrigerant pipes and *AC* condensate drain pipes.

2.2.2 Insulation shall be flexible foamed closed cell elastomeric tubular form type. Insulation may be slipped over pipe or tubing before pipe connections are made, or may be slit longitudinally and snapped on to the pipe and then sealed with vapor barrier adhesive.

2.2.3 Insulation shall have a thermal conductivity not greater than 0.27 BTU /HrOF.ftsq. per inch thickness at a mean temperature of75°F.

2.2.4 The surface finish shall be an8-ounce canvas cloth embedded between 2coats of vapor barrier. Aluminum cladding shall be provided as specified.

2.3 Vapor Barrier Coating

2.3.1 The vapour barrier coating shall be tough flexible fire resistive elastomeric finish for protection of thermal insulation. It shall meet the requirements of NFPA90A and 90Band shall be UL classified.

2.3.2 The vapor barrier shall have water vapor permeability not more than 0.02perms at 0.75 mm dry film thickness when tested to ASTME96 Method.

2.3.3 When tested for surface burning characteristics (ASTME84) it shall have a flame spread rating not exceeding10 and smoke developed not higher than15.

2.3.4 The vapor barrier shall be suitable for application by brush or spray. It shall be applied in 2 coats with heavy duty fire retardant canvas cloth (8ounce) embedded between the coats. Canvas over lap at joints shall be at least 50mm. The wet film thickness of each coats hall be at least1.25mm.

2.3.5 Vapor barrier coating shall be applied above thermal insulation of G.I. Ducts, Water supply (hot and cold), refrigeration and condensate rain pipes.

2.4 **Aluminum Cladding**

2.4.1 Aluminum cladding shall be of 20gauge It shall be used as protection against weather and mechanical damage.

2.4.2 Aluminum cladding shall be applied on top of insulation above the canvas jacket and vapor barrier coating. It shall be held in place by means of self tapping screws and by using 38mm wide aluminum straps at 300mm centers with aluminum or stainless steel angle rib clips, all joints shall be sealed with grey colored suitable sealant. Rivets and screws shall not be used for cladding unless approved by the Engineer for use on elbows and fittings. Cladding shall be over lapping at joints, horizontal seams shall be at the bottom. Cladding on ducts shall be formed in such away to allow for rain/dew drain off.

2.4.3 Fabricated 20gauge aluminum covers shall be used for valves and fittings. The covers shall be in two sections hinged together and held in place by suitable stainless steel/aluminum clasps.

2.4.4 Aluminum cladding shall be applied to all insulated ducts running exposed on roof, outside building, inside parking floors and in plant rooms.

PART 3 EXECUTION

3.1 Protection and Cleaning

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

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

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

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

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

3.1.6 Surface finishes and lagging adhesives shall not be diluted and shall be applied in accordance with themanufacturer's instructions.

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

3.2 Installation of Equipment and Duct Insulation

3.2.1 Curved or cylindrical equipment shall be insulated with blocks or curved segments in one layer for thicknesses of 65mm or less and two layers for thicknesses of 76mm 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.

3.2.2 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.

3.2.3 Insulation inexposed areas, i.e. permanently visible, shall be protected with aluminum cladding as specified.

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

3.2.5 No insulation shall be applied over name plates.

3.2.6 Insulated ducts penetrating walls or floors shall be insulated completely thru penetration. Provide water proof calcium silicate insert, same thickness and jacketing as insulation with wall flange for fire wall or floor penetrations, or as detailed on the Drawings.

3.2.7 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 firewall or penetrates a roof slab.

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

3.2.9 All duct materials and coverings (insulation, pre-insulated panels, linings, etc.) shall meet the requirements of NFPA 90Aand90BStandards or equivalent European Standards.

3.2.10 Adhesives, sealants, vapour barriers, paints, etc., shall meet the requirements of NFPA90A and 90Band shall be UL Classified.

End of Section 23 07 00.

SECTION 23 07 19 – HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Piping insulation.
2. Jackets and accessories.

B. Related Sections:
1. Division 01 Section "General Requirements."
2. Division 01 Section "Special Procedures."
3. Division 09 Section "Painting" for painting insulation jacket".
4. Division 23 Section "Identification for HVAC Piping and Equipment".

1.2 REFERENCES

A. General:
1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

1.3 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Division 01 Section "General Requirements."

B. Subcontractor shall submit the product description, list of materials and thickness for each service, and at each location

1.4 QUALITY ASSURANCE

A. Subcontractor shall assure applicator is a company specializing in piping insulation application with at least 3-years relevant experience.

B. Fire Hazard: Provide insulation, jackets, facings adhesives and accessories acceptable to the State Fire Marshal, and meeting the requirements of NFPA 90A. Meet the following hazard classifications stated in accordance with U.L. Test Method of Fire Hazard Classifications of Building Materials, No. 723:
1. Flame-spread: Maximum 25.
2. Fuel Contributed: Maximum 50.
3. Smoke Developed: Maximum 50.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

A. Mineral-Fiber Insulation: Glass fibers bonded with a thermosetting resin complying with the following:
1. Preformed Pipe Insulation: Comply with ASTM C 547, Type I, with factory-applied, all-purpose, vapor-retardant jacket.
2. Blanket Insulation: Comply with ASTM C553, Type II, without facing.
3. Fire-Resistant Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.

a. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

4. Vapor-Retarder Mastics: Fire and water-resistant. Comply with MIL-C 19565C, Type II.
   a. For indoor applications, use mastics that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
5. Mineral-Fiber Insulating Cements: Comply with ASTM C 195.
6. Expanded or Exfoliated Vermiculite Insulating Cements: Comply with ASTM C 196.
7. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

B. Cellular-Glass Insulation: Inorganic, foamed or cellulated glass, annealed, rigid, hermetically sealed cells, incombustible.
1. Preformed Pipe Insulation, without Jacket: Comply with ASTM C 552, Type II, Class I.
2. Preformed Pipe Insulation, with Jacket: Comply with ASTM C 552, Type II, Class 2.
3. Cellular-Glass, Phenolic, Polyisocyanurate, and Polystyrene Adhesive: Solvent-based resin adhesive, with a service temperature range of minus 75 to plus 300 deg F.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. Prefabricated Thermal Insulating Fitting Covers: Comply with ASTM C 450 for dimensions used in performing insulation to cover valves, elbows, tees, and flanges.

D. Elastomeric Cellular Thermal Insulation: Closed cell, fiber-free elastomeric foam, mold resistant, formaldehyde-free, low VOC and nonparticulating.
1. Sheets: Comply with ASTM C 534, Type II – Sheet Grade 1, ASTM E84, NFPA 255, UL 723, NFPA 90A, 90B.
2. For above ground installation only.
3. For outdoor installation, a weather – resistant protective finish shall be provided per manufacturer’s recommendation.

2.2 FIELD-APPLIED JACKETS

A. General: ASTM C 921, Type I, unless otherwise indicated.

B. Foil and Paper Jacket: Not acceptable.

C. PVC Jacket: High-impact, ultraviolet-resistant PVC; 20 mils thick; roll stock ready for shop or field cutting and forming.
1. Adhesive: Compatible with PVC jacket, and recommended by insulation material manufacturer.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. PVC Jacket Color: White
3. PVC Jacket Color: Color-code piping jacket as determined by existing conditions.
4. Not to be used for outdoors.

D. Heavy PVC Fitting Covers: Factory-fabricated fitting covers manufactured from 30-mil (0.75 mm) thick, high-impact, ultraviolet-resistant PVC.
1. Shapes: 45 and 90-degree, short and long-radius elbows, tees, valves, flanges, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories for the disabled.
2. Adhesive: Compatible with PVC jacket, and recommended by insulation material manufacturer.
   a. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
3. Not to be used for outdoors.

2.3 VAPOR RETARDANTS

A. Mastics: Use materials compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
1. For indoor applications, use mastics that have a VOC content of <**Insert value**> g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 SEALANTS

A. Joint sealants, PVC and metal jacket flashing sealants: For indoor applications, use sealants that have a VOC content of 250 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Install materials after piping has been tested and approved.

B. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

3.3 GENERAL APPLICATION REQUIREMENTS.

A. Apply insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; and free of voids throughout the length of ducts and fittings.

B. Refer to schedules at the end of this Section for material, form, jacket, and thickness required for each piping system insulation requirements.

C. Use accessories compatible with insulation materials and suitable for the service. Use accessories that do not corrode, soften or otherwise attack insulation or jacket when in either wet or dry state.

D. Apply insulation with longitudinal seams at top and bottom of horizontal pipe runs.

E. Apply multiple layers of insulation with longitudinal and end seams staggered.

F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

G. Seal joints and seams with vapor-retardant mastic on insulation indicated to receive a vapor retardant.

H. Keep insulation materials dry during application and finishing.

I. Apply insulation with tight longitudinal seams and end joints. Bond the seams and joints with adhesive recommended by the insulation material manufacturer.

J. Apply insulation with the least number of joints practical.

K. Apply insulation over fittings, valves, and specialties, with continuous thermal and vapor-retardant integrity, unless otherwise indicated. Refer to special instruction for applying insulation over fittings, valves, and specialties.

L. Hangers and Anchors: Where vapor retardant is indicated, seal penetrations in insulation at hangers, supports, anchors, and other projections with vapor-retardant mastic.
   1. Apply insulation continuously through hangers and around anchor attachments.
   2. For insulation application where vapor retardants are indicated, extend insulation on anchor legs at lease 12 inches (300 mm)es from point of attachment to pipe and taper insulation ends. Seal tapered

ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.
3. Install insert materials and apply insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by the insulation material manufacturer.
4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect the jacket from tear or puncture by the hanger, support, and shield.

M. Insulation Terminations: For insulation where vapor retardants are indicated, taper insulation ends. Seal tapered ends with a compound recommended by the insulation material manufacturer to maintain vapor retardant integrity.

N. Apply adhesives and mastics at the manufacturer’s recommended coverage rate.

O. Apply insulation with integral jackets as follows:
1. Pull jacket tight and smooth.
2. Circumferential Joints: Cover with 3 inches (75 mm) wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip and spaced 4-inches o.c.
3. Longitudinal Seams: Overlap jacket seams at least 1 1/2 inches (38 mm). Apply insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4-inches o.c.
4. Exception: Do not staple longitudinal laps on insulation having a vapor retardant.
5. Vapor-retardant mastics: Where vapor retardants are indicated, apply mastic on seams and joints and at ends adjacent to flanges, unions, valves, and fittings.
6. At penetrations in jackets for thermometers and pressure gauges, fill and seal voids with vapor-retardant mastic.

P. Roof Penetrations: Apply insulation for interior applications to a point even with top of roof flashing.
1. Seal penetrations with vapor-retardant mastic.
2. Apply insulation for exterior applications tightly joined to interior insulation ends.
3. Extend metal jacket for exterior insulation occurring outside of roof flashing at least 2-inches below the top of the roof flashing.
4. Seal sheet metal jacket to roof flashing with vapor-retardant mastic.

Q. Exterior Wall Penetrations: For penetration of below-grade exterior walls, terminate insulation flush with mechanical sleeve seal. Seal terminations with vapor-retardant mastic.

R. Interior Wall and Partition Penetrations: Apply insulation continuously through walls and floors.

S. Fire-Rated Wall and Partition Penetrations: Apply insulation continuously through penetrations of fire-rated walls and partitions
1. Fire stopping and fire-resistive joint sealers are specified in Division 07 "Penetration Fire stopping".
2. Floor Penetrations: Apply insulation continuously through floor assembly.
3. For insulation with vapor retardants, seal insulation with vapor-retardant mastic where floor supports penetrate vapor retardant.

3.4 MINERAL-FIBER INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows;
1. Secure each layer of preformed pipe insulation to pipe with wire, tape, or bands without deforming insulation materials.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic. Apply vapor retarder to ends of insulation at intervals of 15 to 20-feet (4.5 to 6 m) to form a vapor retarder between pipe insulation segments.
3. For insulation with factory-applied jackets, secure laps with outward clinches staples at 6 inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply Insulation to flanges as follows:
1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Apply canvas jacket material with manufacturer's recommended adhesive, overlapping seams at least 1 inch (25 mm), and seal joints with vapor-retarder mastic.

C. Apply insulation to fittings and elbows as follows:
1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation elbows and fittings are not available, apply mitered sections of pipe insulation, or glass-fiber blanket insulation, to a thickness equal to adjoining pipe insulation. Secure insulation materials with wire, tape, or bands.
3. Cover fittings with heavy PVC covers. Overlap PVC covers on pipe insulation jackets at least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

D. Apply insulation to valves and specialties as follows:
1. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instructions.
2. When premolded insulation sections are not available, apply glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
3. Apply insulation to flanges as specified for flange insulation application.
4. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
5. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.5 CELLULAR-GLASS INSULATION APPLICATION

A. Apply insulation to straight pipes and tubes as follows:
1. Secure each layer of insulation to pipe with bands without deforming insulation.
2. Where vapor retarders are indicated, seal longitudinal seams and end joints with vapor-retarder mastic.
3. For insulation with factory-applied jackets, secure laps with outward clinched staples at 6-inches o.c.
4. For insulation with factory-applied jackets with vapor retarders, do not staple longitudinal tabs but secure tabs with additional adhesive as recommended by the insulation material manufacturer and seal with vapor-retarder mastic.

B. Apply insulation to flanges as follows:
1. Apply preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation segment the same as overall width of the flange and bolts, plus twice the thickness of the pipe insulation.
3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with cut sections of cellular-glass block insulation of the same thickness as pipe insulation
4. Apply insulation to fittings and elbows as follows:
5. Apply premolded insulation sections of the same material as straight segments of pipe insulation when available. Secure according to manufacturer's written instruction.
6. When premolded sections of insulation are not available, apply mitered sections of cellular-glass insulation. Secure insulation materials with bands.
7. Cover fittings with heavy PVC fitting covers. Overlap PVC covers on pipe insulation jackets as least 1 inch (25 mm) at each end. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.

C. Apply insulation to valves and specialties as follows:
1. Apply premolded segments of cellular-glass insulation or glass-fiber blanket insulation to valve body. Arrange insulation to permit access to packing and to allow valve operation without disturbing insulation. For check valves, arrange insulation for access to strainer basket without disturbing insulation.
2. Apply insulation to flanges as specified for flange insulation application.
3. Use preformed heavy PVC fitting covers for valve sizes where available. Secure fitting covers with manufacturer's attachments and accessories. Seal seams with tape and vapor-retarder mastic.
4. For larger sizes where PVC fitting covers are not available, seal insulation with canvas jacket and sealing compound recommended by the insulation material manufacturer.

3.6 PREFORMED ELASTOMERIC CELLULAR THERMAL INSULATION APPLICAION

A. Apply insulation to straight pipes and tubes as follows:
1. Install pipe insulation by slitting tubular sections and applying onto pipes. Seams and butt joints shall be adhered and sealed using Armaflex 520 adhesive
2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.

B. Apply insulation to valves, flanges and fittings as follows:
1. Insulate with the same insulation thickness as the adjacent piping. Seams and butt joints shall be adhered and sealed with Armaflex 520 adhesive.
2. All edges shall be clean-cut. Rough or jagged edges shall not be permitted.

C. Outdoor insulation shall be protected as follows:
1. Furnish aluminum jacket and aluminum fitting covers.
2. All jackets shall have the seams located below the horizontal plane of the pipes but not at the bottom of the pipe.

D. Indoor insulation shall be protected as follows:
1. Furnish PVC jacket and PVC aluminum fitting covers.
2. All jackets shall have the seams located below the horizontal plane of the pipes but not at the bottom of pipe.

3.7 FIELD-APPLIED JACKET APPLICATION

A. Apply PVC jacket where indicated, with 1 inch (25 mm) overlap at longitudinal seams and end joints. Seal with manufacturer's recommended adhesive.

B. Apply metal jacket where indicated, with 2-inch (50 mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel band 12 inches (300 mm) o.c. and at end joints.

C. Insulation and jacket for cold pipes shall include wicks to direct possible condensation to outside the jacket. The product shall be Knauf PermaWick or equal.

D. Indoor, Concealed Applications: Insulated pipes conveying fluids above or below ambient temperature shall have standard jackets, with or without vapor barrier, factory-applied or field-applied. Insulate fittings, joints and valves with insulation of like material and thickness as adjoining pipe, and finish with glass cloth and adhesive. PVC jackets shall be used.

E. Indoor, Exposed Applications: For pipe exposed in mechanical equipment rooms or in finished spaces, insulate as for concealed applications. Finish with canvas jacket; size for finish painting. PVC jackets shall be used.

F. Exterior Applications: Provide vapor-barrier jackets. Cover with aluminum jackets with seams located below the horizontal plane of the horizontal piping route. Insulate fittings, joints, and valves with insulation of like material and thickness as adjoining pipe, and cover with aluminum jackets.

G. Buried Piping: Provide factory-fabricated assembly with inner all-purpose service jacket with self-sealing lap, and asphalt-impregnated open-mesh glass fabric, with 0.001 inch thick aluminum foil sandwiched between three layers of bituminous compound; outer surface faced with a polyester film.

3.8 PIPING SYSTEM APPLICATIONS

A. Insulation materials and thicknesses are specified in BOQ.

B. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment.
1. Flexible connectors.

2. Vibration control devices.
3. Fire-suppression piping.
4. Drainage piping located in crawl spaces, unless otherwise indicated.
5. Below-grade piping, unless otherwise indicated.
6. Chrome-plated pipes and fittings, unless potential for personal injury.
7. Air chambers, unions, strainers, check valves, plug valves, and flow regulators.

END OF SECTION 230719

SECTION 23-0900

INSTRUMENTATION AND CONTROLS FOR HVAC

SECTION 230900

INSTRUMENTATION AND CONTROLS FOR HVAC

PART 1 GENERAL

1.1 Scope of Work

1.1.1 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.

1.1.2 The sequence of operation of each system or piece of equipment is specified either under the equipment specification section or detailed on the Drawings.

1.2 General Requirements

1.2.1 Control system shall be of the electronic type, (solid state) to provide the required sequence of operation.

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

1.2.3 Unless stated otherwise temperatures shall be controlled within plus or minus 2degree F (1degree C) and humidity within plus or minus 5percent of the set point.

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

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

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

1.2.7 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.

1.2.8 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.

1.2.9 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.

1.2.10 Where thermometer sensing bulbs are inserted in air ducts or casings, provide perforated bulb housing with a3"(80mm) 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 %" (20 mm) separable sockets.

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

1.2.12 All thermometers and gauges shall have both English and metric units grading.

1.3 Shop Drawing

1.3.1 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.

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

1.4 Related Works Specified Elsewhere

1.4.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated herein verbatim. However, any discrepancies between the content of this section and what is shown in Division 25, the specification in Division 25shalltakeprecedence.

Section 230500	-Common Works Results for HVAC
Section 230700	-HVAC Insulation
Section 230900	-Instrumentation And Controls for HVAC
Section 232000	-HVAC Piping and Pumps
Section 233000	-HVAC Air Distribution
Section 234000	-HVAC Cleaning Devices
Section 237000	-Central HVAC Equipment
Section 238000	-Decentralized HVAC Equipment
Division 25	-Integrated Automation

PART 2 PRODUCTS

2.1 Control Panel and Control System

2.1.1 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.

2.1.2 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.

2.2 Temperature Controllers(With Remote Sensors)

2.2.1 Shall be supplied complete with metal cases and manual set point adjusters.

2.2.2 Room type controllers shall be mounted 1800 mm above the floor and in an accessible location.

2.2.3 Panel-mounted controllers shall be supplied with metal mounting adaptor plate and mounting assembly.

2.2.4 Controllers shall be designed for a throttling range of 2 OF(1 ° C) for a 3Vdc output change with a control dial range 55-85 °F(13-29 DC) and shall be suitable for ambient operating limits40-135 OF(4-57 DC).

2.3 Temperature Sensors

2.3.1 Refer to Section 255000- Integrated Automation Facility Controls.

2.4 Room Thermostats

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

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

2.4.3 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 on2OF(1°C) differential and shall have a control dial range 55-85 deg F(13-29 deg C).

2.4.4 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 deg F(13-29 deg C) and a throttling range of2OF(1°C) for a3Vdc output change.

2.5 Control Motor(Actuator)

2.5.1 Electric, reversible, spring-return, proportional type complete with linkage.

2.5.2 Suitable for damper operation.

2.5.3 Shall be sized to operate with sufficient reserve power to provide smooth modulating action or two-position action as specified.

2.6 Humidity Sensors

2.6.1 Refer to Section 255000- Integrated Automation Facility Controls.

2.7 Data Control *(Ole)* and Graphics Summary

2.7.1 All hardware, custom software, application software, graphics, etc., necessary to accomplish the control sequences and display the graphics specified shall be provided as part of this contract. Provide all controllers, inputs, outputs, valves, dampers, actuators and flow meters required to provide the control and graphic data described. Provide software set-points required for display in logical groups and graphics.

2.7.2 Each digital output shall have a software-associated monitored input. Any time the monitored input does not track it's associated command output within a programmable time interval, a" command failed" alarm shall be reported. Where calculated points (such as l/s*)* are shown, they shall appear in their respective logical groups.

2.7.3 Unless otherwise specified or approved prior to bidding, the primary analog input and the analog output of each DOC loop shall be resident in a single remote panel containing the DOC algorithm,. and shall function independent of any primary or UC communication links. Secondary (reset type) analog inputs may be received from the primary network, but approved default values and or procedures shall be substituted in the DOC algorithm for this secondary input if network communications fa i.! or if the secondary input becomes erroneous or invalid.

2.7.4 In addition to the Unitary DOC Controller data points specified to be presented on color graphic displays, technical data for each zone mechanical apparatus shall be presented to operators on the OWS in full English menu text displays including the apparatus name; heating and cooling PID loop P, I and D gains; primary is airflow (if measured); damper position (% open); reheat status/value; cooling set point; heating dead- band; minimum and maximum is set points; reheat is set point; unoccupied temperature set point; temperature sensor calibration offset and bypass push button time, in minutes. All such points shall be presented in complete and direct read-write (command) format, unless they are provided in commendable color graphic displays.

2.7.5 In addition to Graphics of building systems with dynamic data points shall be provided for each mechanical and electrical equipment but not limited.

2.8 Unitary DOC Controllers

2.8.1 All FCU's in lobbies and mechanical rooms shall be provided with DOC based controller with PID control action. The controller shall have communication capability with the 8MB. The BMS shall have the capability of resetting the temperature set point on the FCU Controller.

2.9 Solenoid Valves

2.9.1 Solenoid valves shall be the piston type suitable for cold water, hot water, steam, fuel, oil and other non-aggressive media up to a temperature of 180C. Solenoid Valves shall be sized for 1600kPa with actuators 240Vac.

2.10 Transducers

2.10.1 Analog output transducers shall be designed for precision closed loop control with pneumatic repeatability error no greater than 1%orequal approved.

2.11 Select or Switches Auto/Off/On

2.11.1 Manual override switches AUTO/OFF/ON shall be part of DOC panel/controller. The switches shall be installed inside of DOC panel with necessary auxiliary contacts to DOC controller to indicate selector position. The manual override function shall be available even if the DOC/CPU is failed. The 8MS contractor shall be responsible to coordinate proper connection between the selector switches and starters and ensure that the switches shall provide manual override functions in case that DOC/CPU fails.

2.12 Thermometers

2.12.1 Permanently installed thermometers shall be mercury-in-steel dial type 150mm 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.

2.12.2 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 %"(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.

2.12.3 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..5degree C.

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

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

2.13 Pressure Gauges

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

2.13.2 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.

2.13.3 Bourdon Tube shall be Phosphor bronze, (beryllium copper bellows). Socket shall be Stainless steel.

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

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

2.14 Gauge Test Points

2.14.1 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.

2.14.2 Pressure gauge test points shall consist of6mm. bore bosses in the pipe work fitted with a test cock and plugged *off.*

2.14.3 Air flow 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.

2.14.4 Test points shall consist ofa40mm. diameter hole drilled through the ducting and covered with a removable spring clip fastened cover.

2.15 Filter Condition Indicators

2.15.1 Indicators shall be provided for all air filter units on air handlers and main fresh air louvers. The indicators shall be spirit or moving vane type suitably calibrated and provided with flexible pressure tubes to a test point on each side of all' roughing' and 'fine' filters.

2.15.2 The position on the gauge dial at which the filters require cleaning or changing shall be clearly marked.

2.16 Flow Meters

2.16.1 Supply and install flow meters in the primary chilled water flow line and each refrigeration machine delivery line. The meter connections and cocks shall be carried well above the line.

2.17 Water Flow Switches

2.17.1 Water flow switches shall be of the paddle type electric as manufactured by the McDonnell and Miller Company. Those flow switches used in chilled water applications shall be of the vapor proof type to prevent condensation on the electrical switch.

2.17.2 Paddles shall be properly trimmed for the pipe sizes in which they are installed. The flow switches shall be installed in accordance with manufacturer's recommendations regarding locations in horizontal piping and proper distance from fittings.

2.18 Fire Stats

2.18.1 Provide manual reset fire stat for each fan of750 CFM (0.35 m3/sec) or larger capacity, to stop the fan on rise above set point temperature 136OF(58°C).

2.19 Freeze Stats

2.19.1 Provide a freeze stat for each water coil subject to freezing to protect coil by de energizing the supply fan when triggered.

2.19.2 Freeze stats shall be remote bulb,20ft(6m)averaging type, with manual reset, adjustable set point, 15degrees Fto55degrees F.,(-9to13°C) mechanical stop to limit control point adjustment below predetermined minimum.

2.20 Smoke Detectors

2.20.1 Supply and install duct mounted smoke detectors as shown on the drawings and as required by NFPA code.

2.20.2 Smoke detectors shall be as specified under the Fire Alarm System section of the specifications.

2.20.3 Smoke detectors shall be supplied complete with the necessary power relays and control wiring to perform the proper operations and function specified in the A/C units control diagrams.

2.21 Ammeters

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

2.22 Voltmeters

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

2.22.2 The Voltmeter shall be complete with as even position, rotary switch to enable reading the voltage between all phases and neutral.

2.23 Air Flow Switches' &Dirty Filter Switches

2.23.1 Differential type pressure switches shall be provided for these applications. The switch shall be complete with connecting tube and metal bends for connections to the duct.

PART 3 EXECUTION

3.1 Installation

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

3.1.2 Unless otherwise noted, install all wall mounted thermostats 1400 mm above the floor, measured to the center line of the instruments.

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

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

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

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

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

3.1.8 Locate temperature sensing devices in a portion of the fluid stream where it will measure the average fluid temperature without obstructing flow. Increase pipes 1½"(40 mm) in diameter and smaller at least one pipe size at the point of insertion.

3.2 Testing

3.2.1 After completion of installation, all automatic controls shall be regulated and adjusted and placed incomplete 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.

3.2.2 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.

End of Section 23 09 00.

SECTION 23 21 13 - HYDRONIC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.2 SUMMARY

A. Section includes pipe and fitting materials and joining methods for the following:

1. Hot-water heating piping.
2. Chilled-water piping.
3. Dual-temperature heating and cooling water piping.
4. Condenser-water piping.
5. Makeup-water piping.
6. Condensate-drain piping.
7. Air-vent piping.
8. Safety-valve-inlet and -outlet piping.

1.3 ACTION SUBMITTALS

A. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.
3. Locations of and details for penetrations, including sleeves and sleeve seals for exterior walls, floors, basement, and foundation walls.
4. Locations of and details for penetration and firestopping for fire- and smoke-rated wall and floor and ceiling assemblies.

1.4 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Piping layout, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Suspended ceiling components.
2. Other building services.
3. Structural members.

B. Qualification Data: For Installer.

C. Welding certificates.

D. Field quality-control reports.

E. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.5 QUALITY ASSURANCE

A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

1. Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation.
2. Certify that each welder has passed qualification tests for welding processes involved and that certification is current.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure unless otherwise indicated:

1. Hot-Water Heating Piping: 10 bar
2. Chilled-Water Piping: 10 bar
3. Dual-Temperature Heating and Cooling Water Piping: 10 bar
4. Condensate-Drain Piping: 1 bar
5. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 STEEL PIPE AND FITTINGS

A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; welded and seamless, Grade B, and wall thickness as indicated in "Piping Applications" Article.

2.3 JOINING MATERIALS

A. Welding Filler Metals: Comply with AWS D10.12M/D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.4 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

A. Dual-temperature heating and cooling water piping shall be as follows:
   1. Schedule 40 steel pipe; Class 125, cast-iron fittings; cast-iron flanges and flange fittings; and threaded joints.

B. Condensate-Drain Piping: Schedule 40 PVC plastic pipe and fittings and solvent-welded joints.

C. Air-Vent Piping:

   1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

D. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.

3.2 PIPING INSTALLATIONS

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.

B. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.

C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.

D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

E. Install piping to permit valve servicing.

F. Install piping at indicated slopes.

G. Install piping free of sags and bends.

H. Install fittings for changes in direction and branch connections.

I. Install piping to allow application of insulation.

J. Select system components with pressure rating equal to or greater than system operating pressure.

K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

L. Install drains, consisting of a tee fitting, NPS 3/4 (DN 20) ball valve, and short NPS 3/4 (DN 20) threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.

M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.

N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.

O. Install branch connections to mains using [**mechanically formed**]tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.

P. Install unions in piping, [**NPS 2 (DN 50)**] and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

Q. Install flanges in piping, [**NPS 2-1/2 (DN 65)**] and larger, at final connections of equipment and elsewhere as indicated.

R. Install shutoff valve immediately upstream of each dielectric fitting.

S. Comply with requirements in Section 230516 "Expansion Fittings and Loops for HVAC Piping" for installation of expansion loops, expansion joints, anchors, and pipe alignment guides.

T. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for identifying piping.

U. Install sleeves for piping penetrations of walls, ceilings, and floors.

V. Retain first paragraph below for piping that penetrates an exterior concrete wall or concrete slab.

W. Install sleeve seals for piping penetrations of concrete walls and slabs.

X. Install escutcheons for piping penetrations of walls, ceilings, and floors.

3.3 HANGERS AND SUPPORTS

A. Comply with requirements in Section 230529 "Hangers and Supports for HVAC Piping and Equipment" for hanger, support, and anchor devices. Comply with the following requirements for maximum spacing of supports.

B. Comply with requirements in Section 230548 "Vibration and Seismic Controls for HVAC" for seismic restraints.

C. Install hangers or mounts for steel piping with the following maximum spacing:

1. NPS 3/4 (DN 20): Maximum span, 7 feet (2.1 m).
2. NPS 1 (DN 25): Maximum span, 7 feet (2.1 m).
3. NPS 1-1/2 (DN 40): Maximum span, 9 feet (2.7 m).
4. NPS 2 (DN 50): Maximum span, 10 feet (3 m).

5. NPS 2-1/2 (DN 65): Maximum span, 11 feet (3.4 m).
6. NPS 3 (DN 80) and Larger: Maximum span, 12 feet (3.7 m).

3.4 PIPE JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints: Construct joints according to AWS D10.12M/D10.12, using qualified processes and welding operators according to "Quality Assurance" Article.

E. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.5 TERMINAL EQUIPMENT CONNECTIONS

A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.

B. Install control valves in accessible locations close to connected equipment.

C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.

D. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."

3.6 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

SECTION 23 21 23 - PLUMBING AND HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, Standard General andSupplementary General Conditions, Division 1 Specification Sections, and other applicable Specification Sections including the Related Sections listed below, apply to this Section.

B. Related Sections:

1. Section 220513: Motors.
2. Section 220548: Vibration Control
3. Division 26: Electrical.

1.2 SUMMARY

A. Includes pumps for hydronic and domestic hot water return service.

1.3 SUBMITTALS

A. Submit the following product data for approval:

1. Dimensions and elevations.
2. Performance data/pump curves.
3. Materials of construction.
4. Motor data including motor manufacturer.
5. Vibration isolation and inertia bases

1.4 QUALITY ASSURANCE:

A. Manufacturers and Products: The products and manufacturers specified in this Section establish the standard of quality for the Work. Subject to compliance with all requirements, provide specified products from the manufacturers named in Part 2.

B. Reference Standards: Products in this section shall be built, tested, and installed in compliance with the following quality assurance standards; latest editions, unless noted otherwise.

1. Hydraulic Institute Compliance: Design and manufacture pumps in accordance with ANSI/ Hydraulic Institute Standards.
2. National Electrical Code Compliance: Provide components complying with NFPA 70 National Electrical Code.
3. UL Compliance: Provide HVAC pumps which are listed and labeled by UL, and comply with UL Standard 778 "Motor Operated Water Pumps."
4. Pumps used for potable water service: National Sanitation Foundation NSF/ANSI-61 (potable drinking water) and NSF-61 Annex G (listed as ≤ 0.25% weighted average lead content) (and/or NSF/ANSI-372) and Annex F.

C. Single Source Responsibility: Obtain pumps from a single manufacturer.

1.5 WARRANTY

A. Provide a complete parts and labor warranty for a minimum of one year from the date of Substantial Completion.

PART 2 - PRODUCTS

2.1 GENERAL PUMP REQUIREMENTS:

A. Unless noted otherwise, provide pumps meeting these general requirements.

B. Suitable for the service, rated for the temperature and pressure indicated. When not indicated, pump and pump seals shall be rated for not less than 175 psig working pressure and 225 degrees F continuous water temperature. Provide pumps with capacities and performance as scheduled on the Drawings.

C. Pumps shall have steel shaft, cast iron case, and cast bronze or stainless steel impeller. Flanged pumps shall have suction and discharge taps in flanges, and drain and vent taps in the volute. Piping connections shall be flanged for connection sizes 2 1/2 inches and larger.

D. Pumps shall have statically and dynamically balanced impeller, with a constantly dropping head curve from shutoff to cutoff, and shall not overload their respective motors on any point throughout the head capacity curve. Key and lock impeller to shaft.

E. Motors shall be factory coupled to pump and comply with requirements of Related Section Motors, with rpm, voltage and HP as scheduled. Single phase motors shall have built-in overload protection.

F. Where flexible coupling is specified, coupling shall be EPDM, center dropout type, capable of absorbing torsional vibration and shaft misalignment, complete with ANSI B15.1/OSHA 1910.219 coupling guard.

G. Pumps for domestic water systems shall be lead free (less than 0.25 percent lead by weight in all wetted surfaces) all bronze or stainless steel construction.

H. Pump seals shall be unaffected by chloramines.

I. Pumps used for glycol shall have seals rated for glycol service. J. Pump selection:

1. Select pumps so an impeller/volute is sized to accommodate 10 percent more head than at duty point, unless noted otherwise on pump schedule.
2. Select pump no greater than 85 percent of end of curve flow.
3. Select pump at the point of best efficiency for a given impeller casing combination. Deviations shall be within 3 per- cent of maximum efficiency point on the increasing capacity side of the maximum efficiency point.
4. Maximum Pump Suction velocity:
   a. Inline: 12 fps.
   b. End Suction: 13 fps.
   c. Double Suction: 15 fps.

K. Balance pumps per ANSI / Hydraulic Institute procedures. Perform electronic vibration analysis for all pumps 1/2 hp and above. Un- less noted otherwise, the maximum allowable RMS (filter in) velocity at maximum pump motor speed, measured at each pump and motor bearing, shall not exceed 0.13 inches/sec in the vertical, horizontal and axial directions. For pumps to be applied in variable speed applications, balance and test to assure this vibration limit is not exceeded at any pump speed. Pumps may be field tested after installation by an independent testing agency. Any pump found to exceed the specified vibration limits shall be corrected to perform within those limits without cost to the Owner.

2.2 IN-LINE CIRCULATORS

A. Domestic Hot Water: Close coupled, single suction, lead free bronze or stainless steel impeller and body. System-lubricated, ceramic shaft. Permanently lubricated, bronze or carbon sleeve bearings.

B. Hydronic Systems: Close coupled; single suction bronze or stain- less steel impeller. System-lubricated, alloy steel shaft, Cast iron body. Permanently lubricated sleeve bearings.

C. Rated for 150 psig working pressure, minimum. D.

2.3 IN-LINE HORIZONTAL CLOSE COUPLED PUMPS - HANGER SUPPORTED

A. Close/rigid coupled, single suction impeller. Ceramic mechanical seal. Permanently sealed, permanently lubricated.

B. Domestic Hot Water: Lead free.

C. Pump shall be equipped with an internally flushed seal assembly.

D. Provide universal mount motors that meet NEMA specifications and of size, voltage and enclosure indicated on Drawings. Motor shall be provided with heavy-duty, permanently lubricated ball bearings rated for the maximum load for which the pump is designed.

2.4 FLOOR-MOUNTED, VERTICAL IN-LINE SPLIT COUPLED PUMPS

A. Split-coupled, single suction enclosed impeller. Mechanical seals. Carbon graphite throttle bushing.

B. Pump shall be equipped with an externally flushed seal assembly with manual air vent valve.

C. Provide universal mount motors that meet NEMA specifications and of size, voltage and enclosure indicated on Drawings. Motor shall be provided with heavy-duty, greaseable or permanently lubricated ball bearings rated for the maximum load for which the pump is designed.

2.5 FLOOR MOUNTED, DOUBLE SUCTION PUMPS

A. Single stage, double suction centrifugal, bronze fitted, base mounted, and flexibly coupled pump.

B. Vertical or horizontal split case as indicated, cast iron volute with integrally cast feet, gauge ports at nozzles, vent, and drain ports. Horizontal shaft unless specifically indicated otherwise.

C. Stainless steel shaft designed for less than 0.002 inch deflection, with mechanical seals suitable for temperature and service scheduled, with regreaseable bearings. Bearing life shall be L10 50,000 hr. life minimum. Bearing grease shall be rated to 700 Deg F and resist water/condensation washout.

D. Mechanical carbon face seal rotating against a stationary silicon carbide face.

E. Pump shall be equipped with an internally flushed seal assembly.

F. Impeller shall be of the enclosed double suction type made of low zinc silicon brass or bronze, hydraulically and dynamically bal- anced and keyed to shaft.

G. The pump bearings and mechanical seals shall be serviceable with- out disturbing the upper casing half, piping connections or elec- trical motor connections.

H. Base: Pump and motor shall be mounted on a single, rigid, grouta- ble, welded, structural steel frame.

2.6 END-SUCTION, CLOSE-COUPLED PUMPS

A. Single stage, end suction centrifugal, bronze fitted, close-coupled with base plate.

B. Provide lead free when used for domestic water service.

C. Mechanical seals with ceramic seal seat and carbon seal ring. Oil or grease lubricated, bronze sleeve bearings. Provide slinger on motor shaft between motor and seals to prevent liquid that leaks past pump seals from entering the motor bearings.

D. Back pull-out design to allow pump bearings and seals to be serviced without disturbing piping.

E. Provide universal mount motors that meet NEMA specifications and of size, voltage and enclosure indicated on Drawings.

2.7 FLOOR-MOUNTED, END-SUCTION, FLEXIBLY-COUPLED PUMPS

A. Single stage, end suction centrifugal, bronze fitted, base mounted pump, flexibly-coupled.

B. Vertical split case back pull-out design to allow pump bearings and seals to be serviced without disturbing piping connections or electric motor connections.

C. Wear Rings (if provided as standard): Replaceable, bronze.

D. Mechanical seals with ceramic seat and carbon seal ring. Oil or grease lubricated, bronze sleeve bearings.

E. Base: Pump and motor shall be mounted on a single, rigid, groutable, welded, structural steel frame.

PART 3 - EXECUTION

3.1 GENERAL PUMP INSTALLATION

A. Install the pump as recommended by the manufacturer and as shown on the Drawings. Provide adequate clearance for service access.

B. Independently support piping from the pump casing, regardless of what is recommended by the manufacturer. Demonstrate to the Com- missioner that the piping is independently supported.

C. Fill and vent the system of all air. Purge the pump of air as recommended by manufacturer; check for proper rotation.

D. Place the pump in service and check for proper operation. When required by the Commissioner, record voltage and amperage draw (separate from the T&B contractors work) and provide report to Commissioner.

3.2 IN-LINE PUMP INSTALLATION

A. Install suction and discharge flexible connectors as recommended by the manufacturer and as shown on the drawings.

B. Verify pump is designed for the intended orientation; horizontal versus vertical motor/shaft orientation.

C. Support the pump as recommended by manufacturer. Do not attach supports to motor.

3.3 FLOOR-MOUNTED PUMP INSTALLATION

A. Set pump base level, using stainless steel shims and metal blocks designed for leveling machinery bases. Anchor/attach to base as recommended by the manufacturer. Pre-align, connect piping, re- check alignment, and then grout with non-shrink grout.

B. Provide final alignment in field via laser alignment device, by the manufacturer’s representative. Submit alignment test data for approval. If report indicates pump cannot be aligned properly, correct conditions and re-laser-align.

3.4 COMMISSIONING

A. Perform the commissioning activities as outlined in the Division 01 Section Commissioning and other requirements of the Contract Documents.

3.5 MANUFACTURER INSPECTION AND START-UP

A. For all floor mounted pumps and for all inline pumps greater than 3 HP, after installation and prior to operation, pump manufacturer's factory trained field representative shall inspect the pumps for proper installation and lubrication, final align pump/motor/coupling using laser alignment, conduct start-up, and submit written report.

END OF SECTION 23 21 23

SECTION 2331 00

HVAC DUCTS AND CASING

SECTION 23 31 00

HVAC DUCTS AND CASING

PART 1 GENERAL

1.1 Introduction

1.1.1 This section includes the design, supply, installation testing and commissioning of complete ductwork system for air conditioning fresh air, exhaust and ventilation systems.

1.2 Scope of Work

1.2.1 The contractor shall be responsible for submitting complete above works based on design consultant’s approval of submitted samples, documents etc as per specifications and applicable standards.

1.3 Related Works Specified Elsewhere

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

Section 23 05 00 - Common Works Results for HVAC
Section 23 07 00 - HVAC Insulation
Section 23 09 00 - Instrumentation And Controls for HVAC
Section 23 20 00 - HVAC Piping and Pumps
Section 23 30 00 - HVAC Air Distribution
Section 234000 - HVAC Cleaning Devices
Section 23 70 00 - Central HVAC Equipment
Section 238000 - Decentralized HVAC Equipment
Division 25 - Integrated Automation

1.4 Reference Standards

HVAC DW 144	Sheet Metal Ductwork
NFPA 90A	Standard for the installation of air conditioning and ventilation systems
SMACNA	Sheet Metal and air conditioning contractors national association
ASHRAE	American society of heating, refrigeration and air conditioning
UL 181	underwriters laboratories
ASTM A653-99	Specification for steel sheet, Zinc-coated (Galvnized) by Hot-Dip process

1.5 Ductwork Design Criteria

1.5.1 AU rectangular ducts shall be of the low pressure rating and all circular round ducts shall be of the high pressure rating.

1.5.2 Galvanized sheet steel shall be fabricated, erected and installed in accordance with NFPA 0A and "SMACNA" sheet metal manuals.

1.5.3 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.

1.5.4 Kitchen exhaust ducts shall be constructed and installed in conformance with NFPA 96 and must: Be constructed from carbon steel (for concealed ducts) with a minimum thickness of 1.4 mm and from stainless steel (for exposed ducts) with a minimum thickness of 1.1 mm.

1.5.5 Stair case or lift well pressurization duct shall be fire rated.

1.5.6 Ducts that meant to be used for smoke exhaust shall be fire rated unless:-

1.5.7 It doesn't cross any other fire / smoke zones, i.e. its route within the same fire / smoke zone which it serves.

1.5.8 It is contained solely in a fire rated shaft and no other services included in the same shaft.

1.5.9 All return air ducts inlets shall be fitted with stainless steel wire mesh.

PART 2 PRODUCTS

2.1 Duct work

2.1.1 Galvanized sheet steel ducts shall be of G90 coating designation within ASTM A653-99, 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.

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

2.1.3 Stainless steel ducts shall be of 316 for all Toxic exhaust air in accordance with ASTM Standards and Specifications.

2.2 Duct Hangers and Support

2.2.1 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.

2.3 Flexible Ducts

2.3. 1 Ducts shall be all metal constructed of heavy gauge corrugated aluminium with water tight continuous lock seams.

2.3. 2 Ducts shall be UL 181 Class O non-combustible and complying to NFPA 90A & 90B, or tested to BS 476 (parts 6, 7 & 20) class 1 flame spread and meets the requirements of CP 413 section A2.2.3.

2.3. 3 For air conditioning flexible ducts shall have 25mm thick fiber glass insulation and sheathed in durable polymer vapour barrier.

2.4 Fire Rated Ductwork

2.4.1 2. hours fire resisting ductwork shall be installed where indicated on the drawings or mentioned in Specifications or required by Local Authorities.

2.4.2 Provide complete 2 hours fire rated fire resistive enclosures for smoke and pressurization systems where ductwork is located outside fire rated shaft.

2.4.3 Fire resisting duct and smoke duct shall be manufactured erected and tested in accordance to BS 476 Part 24 ISO 6944.

2.4.4 Fire resisting duct shall prove by test that its cross section area is maintained above 75% when subject to full fire temperature.

2.4.5 Fire resisting duct shall be constructed and protected to insure maintaining the stability, integrity insulation supports, fixing throughout the required period.

2.4.6 Fire resistance filling (fire stopping material) shall seal the clearances between fire resisting duct and wall to insure the stability and integrity of the system.

2.4.7 Fire resisting duct shall be connected to fans by fire rated flexible connectors. Flexible connectors shall be made of glass fabric coated on both sides with flame retardant silver grey polyurethane rubber tested to BS476 Part 20.

2.4.8 All drop rods and exposed bearers shall be insulated in accordance to manufacturer's instructions to assure its fire resistance.

PART 3 EXECUTIONS

3.1 Duct Construction

3.1.1 All ducts shall be constructed and erected so as to be rigid and free from sway, drumming and movement. Duct work 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.

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

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

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

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

3.1.6 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). Flexible duct length shall not exceed 30 cm.

3.1.7 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.

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

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

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

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

3.1.12 Flexible ducts should be kept as short as possible (maximum 30 cm) and fully extended. All slip joints shall be made in the direction of flow.

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

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

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

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

3.1.17 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.

3.1.18 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.

3.1.19 For duct work balancing and testing refer to Section 23 05 93 Subsections 1.3 and 1.4.

3.2 Protection and Cleaning

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

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

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

3.2.4 Operate the fans and thoroughly blowout the interior surfaces of the duct work.

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

3.3 Access Openings in Insulated Ducts

3.3.1 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 vapour seal an access opening, provision shall be made for collecting and draining condensation.

End of Section 23 31 00.

SECTION 23 33 00

AIR DUCTS ACCESSORIES

PART 1 GENERAL

1.1 Introduction

1.1.1 This section includes the design, supply, installation testing and commissioning of all materials for the complete installation of air distribution specialties and duct accessories for the air distribution system.

1.2 Scope of Work

1.2.1 The contractor shall be responsible for submitting complete above works based on design consultant's approval of submitted samples, documents etc as per specifications and applicable standards.

1.3 Related Works Specified Elsewhere

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

Section 23 05 00 - Common Works Results for HVAC
Section 23 07 00 - HVAC Insulation
Section 23 09 00 - Instrumentation And Controls for HVAC
Section 23 20 00 - HVAC Piping and Pumps
Section 23 30 00 - HVAC Air Distribution
Section 234000 - HVAC Cleaning Devices
Section 23 70 00 - Central HVAC Equipment
Section 238000 - Decentralized HVAC Equipment
Division 25 - Integrated Automation

1.4 Reference Standards

UL 555	Standard for fire Dampers and ceiling dampers
NFPA 90A	Standard for installation of air conditioning and ventilating systems
ASTM-A525	Specification for general requirements for steel sheet, zinc-coated (galvanized), by the Hot-dip process.
BS 5588-Part 9	Code of Practice for air-conditioning and ventilation duct work

1.5 Fire Dampers - General Requirements

1.5.1 Fire dampers shall be provided on all duct branches which pierce fireproof floors, walls, shafts, ceilings and as required in accordance with NFPA SECTION NO. 90A.

1.5.2 Assemblies shall be complete with damper blades, fusible links, linkage and stops.

1.5.3 Dampers shall be proportioned and weighed to close at once if released from a link with spring catches and shall stay closed until manually reset.

1.5.4 Dampers and frames shall have suitable peep holes.

1.5.5 Fire damper installation shall guarantee the fire wall integrity.

1.6 Noise Attenuation

1.6.1 The Contractor shall supply and fix acoustic insulation and noise attenuator units where necessary and as shown on drawings and/or required by the Specialist study to reduce the air borne noise transmission through the distribution duct system, so that the specified noise criteria levels are satisfied.

PART 2 PRODUCTS

2.1 Volume Control Dampers

2.1.1 Volume control dampers shall be complete with locking levers and quadrants, indicating their position.

2.1.2 Volume dampers shall be provided whether shown/or not on drawings in main ducts, in all branch ducts supplying three (3) or more air outlets, in all fresh air intakes etc to achieve proper system balancing.

2.1.3 Volume control 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.

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

2.2 Gravity Dampers

2.2.1 Gravity dampers shall consist of:

a. Galvanized sheet steel frame.
b. Aluminum blades.
c. Stainless steel bearing shafts and brass bearings.
d. Neoprene seal to withstand 120°C. air temperature.
e. Aluminum blade travel stop.

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

2.3 Fire Dampers (Curtain Type)

2.3.1 Each fire damper shall have a 2 hour fire protection rating and a 1650 F (73.9 °C) 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.

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

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

2.3.4 All necessary accessories such as sleeves, angles etc. shall be provided for proper installation of fire damper as per manufacturer instructions and it shall finally guarantee the integrity of the fire wall.

2.4 Smoke Dampers

2.4.1 Furnish and install at all locations shown on plans, motorized dampers of the following specifications. Frame shall be minimum of 16 gage galvanized steel formed into a structural hat channel shape with tabbed comers for reinforcement. The blades shall be single skin 16 gage minimum galvanized with three longitudinal grooves for reinforcement. Bearings shall be stainless steel sleeve turning in an extruded hole in the frame. Jamb seal shall be stainless steel flexible metal compression type.

2.4.2 Each damper shall be classified by Underwriters Laboratories as a Leakage Rated Damper for use in smoke control systems. The leakage rating under UL555S shall be leakage Class III (40 cfm/ft.at 1" w.g.).

2.4.3 As part of the UL qualification, dampers shall have demonstrated a capacity to operate (to open and close) under HVAC system operating conditions with pressure of at least 4" w.g. in the closed position and 2000 fpm air velocity in the open position.

2.4.4 In addition to the leakage ratings already specified herein, the dampers and their actuators shall be rated for the elevated temperature anticipated by the smoke but not less than 572°F (300°C). Appropriate electric actuators shall be installed by the damper manufacturer at time of damper fabrication. Damper and actuator shall be supplied as a single entity which meets all applicable UL 555S qualifications for both dampers and actuators. Factory supplied caulked sleeve shall be 20 gage for dampers through 84" wide and 18 gage above 64" wide. Damper and actuator assembly shall be factory tested to assure operation. All wiring or piping material required to interconnect the actuator with detection and/or alarm or SMS system shall be furnished under fire alarm on BMS installation as applicable.

2.4.5 Blade Position Indicator:- Each smoke damper shall be equipped with two position indicator switches linked directly to the damper blade to provide the capability of remotely indicating damper blade position.

2.4.6 For Damper actuator, refer to Section 25 50 00.

2.5 Motorized Dampers

2.5.1 Motorized automatic dampers shall be of the louver type with not less than 13 gauge welded steel frames and galvanized finish. Blades shall have interlocking edges, stainless steel side springs (or vinyl or neoprene gaskets), and teflon-coated stainless steel thrust washers. Blades shall be edged with neoprene if the damper is to operate in outside air service either as an intake or discharge damper. Damper blades shall have steel trunnions mounted in nylon or oilite bearings.

2.5.2 Dampers shall be not more than 1200mm. in length between bearings. Modulating dampers shall be of the opposed blade type unless specified otherwise. Blades shall be not over 200mm. in width and shall not be less than 16 gauge galvanized steel. Hardware shall be zinc plated. One damper actuator shall be provided for each 1.5 sq. meter of damper area.

2.5.3 Provide parallel blade dampers arranged for maximum turbulence and mixing of outside air with return air. Arrange dampers as necessary to prevent stratification or provide baffles necessary to correct stratification problems.

2.5.4 Provide dampers of low leakage construction, so designed that the maximum leakage shall be 10 cfm/ft^2 (0.005 $m3/s/m^2$) of damper with 41"WG. (1 Kpa) pressure differential applied.

2.5.5 For damper actuator specification, refer to Section 25 50 00.

2.6 Flexible Connections

2.6.1 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. The fabric shall have a flame spread rating of not over 25 and a smoke developed rating of not higher than 50.

2.6.2 Flexible connections shall connect ducts across structural expansion joints.

2.6.3 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.

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

2.6.5 Flexible duct connection used for air conditioning, air handling units shall have vinyle coated fabric insulated with 111(25 mm) fiberglass insulation of 0.75 *Ibs/ft3* (12 *Kg/m3)* minimum density, designed to NFPA-90 or BS 5588 part 9 Standards. The connector should be pre-assembled metal to fabric.

2.6.6 The connector shall be 2.4 gauge galvanized zinc to ASTM-A525 G 60.

2.7 Belt Guards

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

2.7.2 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.

2.7.3 The entire assembly shall be rigidly supported.

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

2.7.5 Provide coupling guards on direct-connected units.

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

PART 3 EXECUTION

3.1 Access Openings

3.1.1 <u>General</u>

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

3.1.1.2 All access openings shall be rigidly framed and made air-tight. 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.

3.1.2 Access for Personnel

3.1.2.1 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 air-tight and water-tight sealing between the door and the duct. All personnel access openings shall have latch handles on both the inside and outside of the door.

3.1.3 Access for Maintenance. Cleaning and Inspection

3.1.3.1 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 air-tight sealing.

3.1.4 Test Holes for Test Equipment and Instruments

3.1.4.1 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.

3.1.5 Access Openings in Insulated Ducts

3.1.5.1 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 vapour seal an access opening, provision shall be made for collecting and draining condensation.

End of Section 23 33 00

SECTION 23 34 00

HVAC FANS

SECTION 23 34 00

HVAC FANS

PART 1 GENERAL

1.1 Scope of Work

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

1.1.2 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.

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

1.2 Related Works Specified Elsewhere

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

Section 23 05 00 - Common Works Results for HVAC
Section 23 07 00 - HVAC Insulation
Section 23 0900 - Instrumentation And Controls for HVAC
Section 23 20 00 - HVAC Piping and Pumps
Section 23 30 00 - HVAC Air Distribution
Section 234000 - HVAC Cleaning *Devices*
Section 237000 - Central HVAC Equipment
Section 23 80 00 - Decentralized HVAC Equipment
Division 25 - Integrated Automation

1.3 Codes and Standards

1.3.1 Codes and standards applicable to this section shall be primarily British Standards and United States Codes, unless otherwise specified, the performance/manufacturing standards of items mentioned in this section shall confirm to the applicable portions of the latest editions of the following codes, standards and regulations.

Reference Code	Abbreviation	Applicable Standard	Title of Standard
American Society of Heating Refrigeration and Air Conditioning	ASHRAE	-	-
National Electrical Manufacturers Association	NEMA	-	-
National Electrical Code	NEC	Section 424	-
Air Moving and Conditioning Association	AMCA	-	-

National Fire Protection Association	NFPA	NFPA 90A	Standard for Air Coditioning and Ventilation Systems
Underwriters Laboratories	UL	UL181	-
American Standards for Testing and Materials	ASTM	ASTM A525-75	Specification for general requirements for steel, Zinc-coated(galvanized) by the hot-dip process

1.4 General Requirements for Ventilating Fans

1.4.1 The fan motors and starters shall be in accordance with the Electrical division of these specifications.

1.4.2 Test and rate all fans in accordance with the standards of the AMCA. All fans must bear the AMCA certified rating seal.

1.4.3 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.

1.4.4 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.

1.4.5 Drill all fan shafts on the center line to receive a tachometer.

1.4.6 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.

1.4.7 Bearings shall be self-aligning, grease lubricated, ball-bearing type, and shall be complete with grease fittings, extended for easy access where necessary.

1.4.8 Weather proof hoods should be provided for all motors and drives exposed to weather to the approval of the Engineer.

1.4.9 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.

1.4.10 Fans scheduled for the exhaust of kitchen equipment. hoods and high temperature exhaust systems shall include an up blast arrangement on the discharge with complete grease drainage and insulated heat shield to protect motor and drive, all designed for high temperature services.

1.4.11 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.

1.4.12 Performance curves shall be submitted for each fan for approval.

1.4.13 Fans power shall not exceed 2.8 Watt/Lit/Sec. or as requested by LEED/GREEN requirements.

PART 2 PRODUCTS

2.1 Centrifugal In-Line Fan (Smoke/Fume Fans)

2.1.1 Fan shall be of the centrifugal in-line type steel construction and shall be complete with:

a. Electric motor mounted outside the air stream.
b. Metallic fixing frame and supports.
c. Dust proof, non fused disconnect switch under motor casing.
d. Belt drive and belt guard.
e. Vibration isolators.
f. All aluminium centrifugal backward inclined blades impeller with non overloading horse power characteristic.
g. Flexible duct connection at each end.
h. Fans used for smoke exhaust shall have all welded housing with motors and all parts rated for the high temperature anticipated by the smoke, but not less than 752°F (400°C).
i. Electric meter shall be of variable speeds if shown in capacity schedule.

2.1.2 Fans shall be supplied complete with minimum IP55 sheet steel control panel. The panel shall include but shall not be limited to the following:-

a. Door interlocked disconnect switch.
b. Duty alternator (where needed)
c. Circuit breaker.
d. Motor starters
e. On/Off/Auto with pilot light
f. Control power transformer
g. Control wiring
h. Volt free contacts for connection to BMS
i. Single phasing protection

2.1.3 Fans shall be coated at the factory with anti corrosion coating as recommended by the manufacturer.

2.2 Centrifugal In-Line Fan (Up to 500 cfm)

2.2.1 Fan shall be constructed of steel with epoxy finish highly resistant against atmospheric agents. Fan shall have back inclined impeller fixed and balanced directly on the motor. Electrical connections shall be enclosed in a plastic box with IP54 protection. All fans exhausting air from the dryer shall be rated for 60 degree C air temperature.

2.3 Centrifugal Single Inlet Fans (Staircase I Lift Well Pressurization)

2.3.1 Pressurization fan shall be of the centrifugal single inlet backward curved blades type with two-piece housing where wheel, shaft and inlet pan assembly installed in lower housing section. Average life of fan bearing shall not be less than 200,000 hours. Fan shall be complete with:

a. Electric motor mounted on one chassis with the fan.
b. Reinforced heavy gauge fan casing.
c. Metallic fixing frame and supports.
d. Dust proof, non-fused disconnect switch.
e. Pulleys, belt drive and belt guard.
f. Spring vibration isolators.
g. Heavy flanges on both sections of housing for assembly. Flanged joints shall be gasketed for air tightness.
h. Galvanized steel mesh screen.
i. Non-return damper
j. Fans shall be supplied complete with minimum IP55 sheet steel Control Panel (CP) as indicated in Electrical Drawings. The panel shall include but shall not be limited to the following:-

   - Door interlocked disconnect switch
   - Duty alternator (where needed)
   - Circuit breaker
   - Motor starters
   - On/Off/Auto with pilot light
   - Control power transformer
   - Control wiring
   - Volt free contacts for connection to BMS
   - Single phasing protection.

2.3.2 Fans shall be coated at the factory with anti corrosion coating as recommended by the manufacturer, for outdoor use in high temperature and humid atmosphere.

2.3.3 Fans shall be interlocked with fire alarm panel to be activated in case of fire in any particular zone.

2.4 Vane Axial Fans

2.4.1 Each fan shall be of the axial type with belt driven aerofoil impeller. Casing shall be fabricated from mild steel hot dipped galvanized after manufacture.

2.4.2 Each fan shall be complete with:

- Electric motor mounted on fan casing.
- Sealed ball bearings

- V-belt with bullies keyed to the shaft.
- Belt tuner and screen.
- Integral guide vanes.
- Protection ground.
- All parts of Fan used for smoke exhaust shall be rated for the high temperature
- anticipated by the smoke, but not less Thant 752 of (400°C).

2.5 Wall Propeller Exhaust Fan

2.5.1 Wall exhaust fan shall be of the wall or window mounted type all plastic construction.

Fan shall be complete with outside plastic grille, enough length of electrical flexible cord (including ground conductor) with suitable connecting end (plug, or ..) to connect to electrical outlet, and wall mounted on-off switch. Fan shall have a shutter that opens and closes automatically by means of an electromagnet.

2.6 Exhaust Fan

2.6.1 Shall be of the centrifugal single inlet backward curved blades type with two-piece housing where wheel, shaft and inlet pan assembly installed in lower housing section. Fan shall be complete with:

2.6.1.1.1 Electric motor mounted on one chassis with the fan.

2.6.1.1.2 Reinforced heavy gauge fan casing.

2.6.1.1.3 Metallic fixing frame and supports.

2.6.1.1.4 Dust proof, non-fused disconnect switch.

2.6.1.1.5 Pulleys, belt drive and belt guard.

2.6.1.1.6 Vibration isolators.

2.6.1.1.7 Heavy flanges on both sections of housing for assembly. Flanged joints shall be casketed for air tightness.

2.7 Centrifugal In-Line Fan (Not for Smoke)

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

2.7.1.1 Electric motor mounted outside the air stream, when air temperature inside the duct is above 200 of (93°C), otherwise inside air stream.

2.7.1.2 Metallic fixing frame and supports.

2.7.1.3 Dust proof, non fused disconnect switch under motor casing.
2.7.1.4 Belt drive and belt guard or as stated in Capacity Schedule.
2.7.1.5 Vibration isolators.
2.7.1.6 Aluminium air foil blades impeller with non overload.ing horse power characteristic.

2.7.1.7 Flexible duct connection at each end.

2.8 Roof Ventilators

2.8.1 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.

2.8.2 Each roof ventilator shall be complete with:

2.8.2.1 Electric motor suitable for outdoor operation.

2.8.2.2 Aluminium protective cowl and body
.

2.8.2.3 Metallic fixing and supporting frame.

2.8.2.4 Weather proof non fused disconnect switch under fan cowl.

2.8.2.5 Galvanized steel bird screen.

2.8.2.6 Automatic shutter

2.9 Centrifugal Exhaust Ventilator (Roof Or Wall Mounted)

2.9.1 Fan to be spun Aluminium centrifugal exhauster belt or direct, driven, down blast or horizontal discharge and shall be wall or roof mounted as applicable and shown on drawings. Fan shall be UL listed and shall bear the AMCA certified ratings seal for sound and air performance.

2.9.2 The fan shall be bolted and welded construction utilizing corrosion resistant fasteners spun Aluminium structure shall be minimum 16 gauge marine alloy Aluminium. The motor, bearings and drives shall be mounted on a minimum 14 gauge steel power assembly with vibration isolation, these components shall be enclosed in a weather tight compartment separated from airstream. Wheels shall be centrifugal backward inclined, constructed of 100% Aluminium, wheel vanes shall be welded to the inlet cone to ensure permanent wheel stability and alignment, wheels shall be balanced in accordance with AMCA standard 204-96.

2.9.3 Bearings shall be heavy duty with average life of 200,000 hours. Belts shall be of oil and heat resistant, non-static type. Drives shall be machined cast iron sized up to 150% of installed motor HP. Variable pitch motor drive must be factory set to the specified fan rpm.

2.9.4 Each fan shall be complete with:-

2.9.4.1 Heavy duty electric motor suitable for outdoor operation with permanent lubrication.

2.9.4.2 Aluminium protective cowl and body.

2.9.4.3 Metallic fixing and support.ing frame.

2.9.4.4 Weatherproof non fused disconnect switch under fan cowl.

2.9.4.5 Galvanized steel bird screen.

2.9.4.6 Automatic shutter

2.9.4.7 Control panel.

2.10 Ceiling Mounted Exhaust Fan

2.10.1 Ceiling exhaust fan shall be of the centrifugal double inlet fan with bottom intake through an extruded aluminium grille, and horizontal ducted discharge. Casing shall be of rigid formed steel housing with baked enamel finish. Unit shall be complete with:

2.10.1.1 Motor with vibration isolators.

2.10.1.2 Enough length of electrical flexible cord with disconnect plug and integral electrical knockouts, accessible from outside ..

2.10.1.3 Shutter which closes automatically by means of an electromagnet when the exhaust fan is off.

2.11 Belt Driven Wall Exhaust Fans

2.11.1 Fan shall be of the propeller, wall mounted, belt drive type.

2.11.2 Fan shall be supplied complete with the following:

2.11.2.1 Totally enclosed electric motor complete with cast aluminium drive assembly.

2.11.2.2 Cast aluminium bladed propeller with separate blades mounted in a cast aluminium hub, propeller shall be statically and dynamically balanced.

2.11.2.3 Removable polyvinyl coated screen at inlet side.

2.11.2.4 Sealed ball bearings.

2.11.2.5 Motorized aluminium damper at outlet.

2.11.2.6 Aluminium casing with adjustable anchor angle and aluminium frame.

2.12 Fresh Air Fans

2.12.1 Fan shall be of the centrifugal double inlet width, 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.

2.12.2 Fan shall be supplied complete with:

2.12.2.1 Electric motor mounted on one chassis with the fan.

2.12.2.2 Reinforced heavy gauge fan casing.

2.12.2.3 Metallic fixing frame and supports.

2.12.2.4 Pulleys, belt drive and belt guard (of expanded metal with tachometer hole).

2.12.2.5 Vibration isolators.

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

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

2.12.2.8 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.

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

2.13 Spare Parts

2.13.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

2.14 Special Tools

2.14.1 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

2.15 Operation and Maintenance Manuals

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

2.15.1.1 Brief description of each system and its service and basic operation features.

2.15.1.2 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.

2.15.1.3 Maintenance instructions for each type of equipment.

2.15.1.4 Possible breakdowns and repairs for each type of equipment. List of nearest local suppliers for all equipment.

2.15.1.5 Manufacturer's literature describing each piece of equipment control diagrams and wiring diagrams of controllers.

2.15.1.6 Complete, as installed, colour coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

2.15.1.7 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

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

2.16 Guarantee and Warranted Period

2.16.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.

2.16.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.

2.16.3 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 substantial completion certificate.

End of Section 23 34 00.

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 GENERAL

PART 2 PRODUCTS

PART 3 EXECUTION

(NOT USED)

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 GENERAL

1.1 Scope of Work

1.1.1 Works of this section shall be governed by Contract Conditions requirements.

1.1.2 Variable Air Volume (VAV) Units shall be as per the capacities shown on drawings and/or indicated in Bill of Quantities. Special attention should be made for the upper & downstream pressure when selecting the VAV.

1.2 Related Works Specified Elsewhere

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

Section 23 05 00 - Common Works Results for HVAC
Section 23 07 00 - HVAC Insulation
Section 23 09 00 - Instrumentation And Controls for HVAC
Section 23 2000 - HVAC Piping and Pumps
Section 23 30 00 - HVAC Air Distribution
Section 234000 - HVAC Cleaning Devices
Section 23 70 00 - Central HVAC Equipment
Section 23 80 00 - Decentralized HVAC Equipment
Division 25 - Integrated Autoation

2 PRODUCTS

2.1 Constant Air Volume Terminal Units (CAV)

2.1.1 Supply and install CAV terminal units, of the same construction and insulation as the variable air volume (Pressure Independent) type terminal units.

2.1.2 The units shall have multi-leaf opposed blade dampers with neoprene seal and external linkage flange connected.

2.2 Variable Air Volume Terminal Units (Bypass Type)

2.2.1 Supply and install VAV terminal units of the by-pass type wherever shown on the drawings and of sizes and capacities as indicated there upon. Each terminal unit shall be electrically controlled and shall be supplied complete with:

2.2.1.1 <u>GENERAL</u>

2.2.1.1.1 Casing shall be welded 22-gauge galvanized steel with hanger holes at the four corners. Maximum casing leak rate shall not exceed 4% of nominal rating at 0.50 inches w.g. Unit shall have one round primary air inlet, one rectangular discharge outlet to the room and one round bypass discharge outlet.

2.2.1.1.2 Insulation-Interior surface of unit casing shall be acoustically and thermally lined with ½ inch, 1.9 Ib/cu. ft. density glass fiber with high density facing. Insulation shall be UL listed and meets NFPA 90A and UL 181.

2.2.1.1.3 Bypass Balancing Damper - A field adjustable balancing damper shall be provided on the bypass outlet.

2.2.1.1.4 Discharge Duct Connection - Straight flanged rectangular discharge duct connection.
2.2.1.1.5
2.2.1.2 Electronic Controls

2.2.1.2.1 Electric Air Valves - Two, cylindrical airflow control devices, each with an integral 24 VAC electric actuator. The air valves modulate to provide variable airflow to the room in response to the room thermostat while maintaining constant primary unit airflow at unit inlet. Includes an eight-point, averaging flow sensing ring for airflow measurement to within 5% pf rated unit airflow, with 1 ½ diameters of straight upstream ductwork. Integral flow taps and calibration chart shall be provided on each unit. Leakage rate shall be less than 1% of nominal unit CFM at four inches inlet static pressure. Unit mounted potentiometers shall be provided for field adjustment of minimum and maximum airflow settings.

2.2.1.3 <u>Thermostat</u>

2.2.1.3.1 A remote room type thermostat shall be installed wherever shown on the Drawings. The thermostat shall be field wired to the circuit board.

2.3 Spare Parts

2.3.1 The Contractor shall provide as part of his contract a list of spare parts for all the equipment supplied sufficient for three years of operation all in accordance with the recommendations of the manufacturers of the equipment.

2.4 Special Tools

2.4.1 A complete set of special tools, oil and grease for all the plant and equipment supplied, adequate for 12 months operation shall be supplied by the Contractor at the completion date of the project.

2.5 Operation and Maintenance Manuals

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

2.5.1.1 Brief description of each system and its service and basic operation features.

2.5.1.2 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.

2.5.1.3 Maintenance instructions for each type of equipment.

2.5.1.4 Possible breakdowns and repairs for each type of equipment.

2.5.1.5 List of nearest local suppliers for all equipment.

2.5.1.6 Manufacturer’s literature describing each piece of equipment control diagrams and wiring diagrams of controllers.

2.5.1.7 Complete, as installed, colour coded wiring diagrams of all electrical motor controller connections and interlock connections of other mechanical equipment.

2.5.1.8 The Contractor shall furnish all the foregoing to the Engineer for his review as to the fulfillment of the specified requirements.

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

2.6 Guarantee and Warrantee Period

2.6.1 All equipment and accessories supplied by the nominated Sub-Contractor under this contract shall be guaranteed for a minimum period of one year from the date of final completion certificate.

2.6.2 All guarantee shall be unconditional. In the event of breakdown, the Contractor shall immediately provide and install a replacement unit of equal or superior performance until such time as the original unit is repaired. Failure by the Contractor to comply within 6 hours of notification, will entitle the Employer to purchase or hire a replacement and seek reimbursement from the Contractor for all related disbursements.

2.6.3 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 Substantial completion certificate.

2.6.4 The Contractor shall issue a letter of guarantee for every compressor installed under his contract for a period of five years, starting from the date of issue of the substantial completion certificate. Contractor shall replace the defective compressor by a new one and shall submit a report to the Engineer explaining the reason of damage and methods to cure it.

PART 3 EXECUTION (NOT USED)

End of Section 23 36 00.

SECTION 23 37 00

AIR OUTLETS AND INLETS

SECTION 23 37 00

AIR OUTLETS AND INLETS

PART 1 GENERAL

1.1 Introduction

1.1.1 This section of specification includes the design, supply, installation testing and commissioning of the Air inlets and outlets for the complete air conditioning and ventilating system including fresh air intakes, louvers, grilles, diffusers etc.

1.2 Scope of Work

1.2.1 The contractor shall be responsible for submitting complete above works based on design consultant's approval of samples, submitted documents etc as per specifications and applicable standards.

1.3 Related Works Specified Elsewhere

1.3.1 The works specified in the following divisions, sections and sub-sections are included in this Section in each applicable part, as if repeated here in verbatim.

Section	230500	-Common Works Results for HVAC
Section	230700	-HVAC Insulation
Section	230900	-Instrumentation AndControls forHVAC
Section	232000	-HVAC Piping andPumps
Section	233000	-HVACAirDistribution
Section	234000	-HVACCleaning Devices
Section	237000	-Central HVAC Equipment
Section	238000	-Decentralized HVAC Equipment
Division	25	-Integrated Automation

1.4 ReferenceStandards

DW 142	British Heating and Ventilating Contractors Association Code of Practice
NP 90A	Standard for the installation of Air Conditioning and Ventilating Systems
ADC	Air Diffusion Council

1.5 Air DistributionOutlets General Requirements

1.5.1 All air outlets shall be of, at least the sizes indicated onthe Drawings. Irrespective of the sizes indicated on drawings, diffusers/grillers shall be sized such that the noise spectrum ofthe supply outlets not higher than NC-25 but inall cases outlet selected shall perform within the noise level requirement of the space it is supplying. Outlets shall be supplied with foam rubber gaskets to prevent air leakage.

1.5.2 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 aluminum of the color specified or as selected by the Engineer.

1.5.3 Outlets causing excessive air movement, drafts or objectionable noise shall be replaced at no cost to the owner.

1.5.4 All outlets shall be powder coated, samples showing finish and color shall be submitted to the Engineer for approval prior to supplying the outlets to Site.

1.5.5 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.

PART 2 PRODUCTS

2.1 Square-Air Diffusers

2.1.1 Air diffusers shall be of the diffusion and air mixing type and shall be made of anodized aluminum.

2.1.2 Supplied air shall be diffused with no air velocities in excess of 50 FPM. (0.25 *m/s)* at 1800 mm height 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.

2.1.3 Each diffuser shall be provided with an aluminum opposed blade damper.

2.1.4 Diffuser shall not project appreciably below ceiling or duct.

2.1.5 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.

2.1.6 The noise level shall be measured at a point one meter below the diffuser.

2.2 Linear Diffusers

2.2.1 Continuous slim line diffusers shall have extruded white anodized aluminum vanes and frames, unless otherwise indicated on the Drawings, and shall be designed for surface mounting on wall, ceiling or sill.

2.2.2 Diffusers shall be capable of diffusing air in a horizontal or vertical plane, combining discharge air diffusion, 20% aspiration and secondary air motion causing the discharge air to be diffused in such a manner that the air is delivered in a multiplicity of high and low pressure air currents causing turbulent air motion and insuring complete coverage and temperature uniformity within the space served.

2.2.3 The diffuser shall be provided with equalizing deflector and damper to accomplish uniform distribution throughout the length of the outlet.

2.2.4 The noise level shall be measured at a point 1800mm below on either side of the diffuser.

2.3 Linear Bar Grilles

2.3.1 Linear grille shall have extruded polyester powder coated aluminum fixed bar and frames, unless otherwise indicated on the drawings and shall be designed for surface mounting.

2.3.2 Grilles shall be capable of diffusing air in a horizontal or vertical plane with 0° to 15°or 30° deflection. Air shall be diffused in such a manner that the air is delivered in a multiplicity of high and low pressure air currents causing turbulent air motion and insuring complete coverage and temperature uniformity within the space served.

2.3.3 The grille shall be provided with directional blades and damper to accomplish uniform distribution throughout the length ofthe outlet. All deflection bars shall be securely fixed and shall be parallel to the long dimension.

2.3.4 The noise level shall be measured at a point 1800mm below on either side of the diffuser.

2.4 Grilles and Registers

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

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

2.4.3 Supply registers shall be double deflection, horizontal face bars, air foil blade construction, with aluminum opposed blade, key operated volume dampers, and 19 mm minimum gasket flange.

2.4.4 Return grille at low levels 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.

2.5 Fresh Air and Discharge Louvers

2.5.1 Louvers for fresh air intake, and for exhaust. They shall be white anodized aluminum.

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

2.5.3 Louvers shall be furnished with ½”(13mm) mesh-bird screen secured in removable extruded Aluminum frames.

2.6 Sand Trap Louvers

2.6.1 Sand trap louver shall have a high degree of separation of sand and large dust particles, even in cases of high dust concentrations. The vertically arranged sections and holes for sand drainage shall ensure the sand trap louver is self-cleaning and maintenance free. The sand trap louver shall be designed to separate large particles at low air velocities, thus avoiding excessive dust loading.

2.6.2 The sand trap louver shall be constructed in polyester powder coated aluminum, and shall be complete with transom, sand chute and galvanized bird screen. Color shall be to Engineer’s approval.

2.6.3 Whether shown on drawings or not, all fresh air intakes shall be with sand trap louvers, filters and volume control dampers.

2.7 Door Louvers

2.7.1 The door louvers shall be sized so that the face velocity does not exceed 250 fpm (1.3*m/s)* unless otherwise indicated on the Drawings.

2.7.2 The louver shall be extruded aluminum completely light proof V-Section with double frame.

2.8 DRUM TYPE LOUVRES

2.8.1 Drum type louvers shall be fabricated of extruded aluminum sections with felts all around the rotating drum to prevent air leakage. Louvers shall have satin anodized aluminum finish.

2.8.2 The louver shall be adjustable to direct the air stream at any angle up to 30 $^{\circ}$ from the louvres centerlines either byrotating the drum orbyadjusting the position ofthe pivoted vanes.

PART 3 z EXECUTION

3.1 Installation

3.1.1 All outlets shall be erected, leveled 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.

3.2 Fixing

3.2.1 All outlets shall be concealed fixing type with no screws.

3.3 Rejected

3.3.1 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.

End of Section 23 37 00.

**SECTION
23 40 00**

**AIR CLEANING
DEVICES**

SECTION 23 40 00

AIR CLEANING DEVICES

PART1 GENERAL

1.1 Introduction

1.1.1 This section includes the design, supply, installation, testing and commissioning of complete aircleaning devices forairconditioning systems.

1.2 Scope of Work

1.2.1 The contractor shall beresponsible forsubmitting complete above works based ondesign consultant's approval of submitted samples, documents etc as per specifications and applicable standards.

1.3 RelatedWorks Specified Elsewhere

1.3.1 The works specified in the following sections are included in this Section in each applicable part,asifrepeated herein verbatim.

Section 230500	-Common Works Results forHVAC
Section 230700	-HVAC Insulation
Section 230900	-Instrumentation andcontrol forHVAC
Section 233000	-HVACAirDistribution
Section 235000	-Central Heating Equipment
Section 2360 00	-Central Cooling Equipment
Section 237000	-Central HVAC Equipment
Section 238000	-Decentralized HVAC Equipment
Division 25	-Integrated Automation

1.4 ReferenceStandards

1.5 GeneralRequirements

1.5.1 Provide temporary filter elements in the filter banks of supply systems used during construction priortousing thesystem.

1.5.2 Temporary filter elements shall be throw-away type with frames taped air-tight.

1.5.3 Immediately prior to test and balance operations, replace temporary filters with a new set of specified filter elements.

1.5.4 After final acceptance, a new set of filter elements shall either be delivered to owner or installed to replace 'Test" filters, as directed by Owner.Provide throw-away filters ofthickness tofitframes ofunitary equipment.

PART 2PRODUCTS

2.1 FILTERELEMENTS

2.1.1 <u>Throw-away Filter</u>

2.1.1.1 Throw-awayfilters - 2" (50 mm) thick fiberglass media contained in rigid frame with a supporting maze across bothentering and leaving faces ofMedia. Minimum average 10% NBS efficiencywith atmospheric dust. Maximum 0.17” WG. (42 pa) initial resistance at500 FPM(2.5*m/s)face*velocity.

2.1.1.2 Provide throw-away filters ofthickness tofitframes ofunitary equipment.

2.1.2 <u>BagFilter</u>

2.1.2.1 Bag type filters shall be supported on substantial wire mesh frames fixed ina housingassembly containing thefilter bags. The housing frames shall be drilled for assembly into a multiple battery suitable for mounting directly onto the downstream side ofthe outdoor louvers orgrilles..

2.1.2.2 Each bag is made up from three distinct layers of filter media. The first layer should provide dust holding capacity forlonglife,thesecond finefiltration ofsmaller particles and thethird prevent fiber migration.

2.1.2.3 Bag filters shall have an initial clean filter resistance toair-flow notexceeding 0.28" WG. (70 pa)andafinal resistance (dirty) notexceeding OS WG. (12Spa). The first layershalt beof graduated density continuous filament glass, the second layer shall consist ofthe fiberglass orsynthetic media, while thethird layershallconsist ofspun nylon backing.

2.1.3 <u>GreaseFilters</u>

2.1.3.1 Grease filters- 2”(50mm)thick, constructed ofcross-pleated layers offinemesh aluminum media with aluminum frame. Filter shall bethe high capacity, low resistance type which can becleaned inhotwater with ahousehold detergent maximum initial resistance shall be0.111wg(25pa)atarated facevelocity ofSODFPM(2.S*m/s).*

2.1.4 <u>Cleanable Filter</u>

2.1.4.1 Cleanable filter: 2" (50mm)thick aluminum media, contained inaluminum frame. Filter shall have an average efficiency of 60 %, and itshall be capable of being completely cleaned byflushing with tap water. Holding frames shall be provided with polyurethane seals andstainless steel spring latches.

2.1.5 <u>Framing System:</u>

2.1.5.1 The filter bankframing shall bemadefrom extruded aluminium framing members having a minimum thickness of0.09”Allmembers shall becuttosize and pre-punched foreasyassembly intomodules ofthesizeandcapacity required.

2.1.5.2 The framing member shall be permanently gasketed to prevent the bypass of unfiltered air. Vertical support members shall be provided if required to prevent deflection of horizontal member, andshall notinterfere withthe installation ortheoperation ofthefilter. The extruded members shall incorporate aseparate track forpre-filters..Allfilters shall be held inplace with necessary fasteners which can beinstalled without the useoftools. A factory installed positive sealing device for each row of filters shall be incorporated in the framing system. Framing system modules shall besupplied complete with all necessary accessories for field assembly.

<u>End of Section 23 40 00.</u>

SECTION 23 64 27 – AIR-COOLED WATER CHILLERS

PART 1 - GENERAL

1.1 SUMMARY

A. Related Documents:
1. Drawings and general provisions of the Subcontract apply to this Section.
2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
1. Design and construction of air-cooled chiller
2. Starters with disconnect switches
3. System control panel
4. Refrigerant charge, oil, and like start-up materials
5. Testing, start-up and instruction
6. Manufacturer’s field services for start-up and instruction.

C. Related Sections:
1. Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment".
2. Division 23 Section "HVAC Piping Insulation".
3. Division 23 Section "HVAC Equipment Insulation".
4. Division 23 Section "HVAC Pumps".

1.2 REFERENCES

A. General:
1. The following documents form part of the Specifications to the extent stated. Where differences exist between codes and standards, the one affording the greatest protection shall apply.
2. Unless otherwise noted, the referenced standard edition is the current one at the time of commencement of the Work.
3. Refer to Division 01 Section "General Requirements" for the list of applicable regulatory requirements.

B. Air Conditioning and Refrigeration Institute (ARI):
1. ARI 550 Centrifugal and Rotary Screw Water-Chilling Packages
2. ARI 575 Method of Measuring Machinery Sound within an Equipment Space

C. American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE):
1. ASHRAE 15 Safety Code for Mechanical Refrigeration
2. ASHRAE 30 Methods of Testing Liquid Chilling Packages

D. ASTM International:
1. ASTM C 117 Test Method for Materials Finer than 75-Micrometer (No. 200) Sieve in Mineral Aggregates by Washing
2. ASTM C 335 Test Method for Steady-State Heat Transfer Properties of Horizontal Pipe Insulation

E. National Electrical Manufacturers Association (NEMA):
1. NEMA 250 Enclosures for Electrical Equipment (1000 Volt Maximum)
2. NEMA ICS 6 Enclosures for Industrial Control and Systems

F. National Fire Protection Association NFPA 70 National Electrical Code

G. National Institute of Occupational Safety and Health NIOSH TC-13F-4

H. Underwriters Laboratories, Inc. (UL)

I. 40 CFR Part 82 Protection of Stratospheric Ozone

J. National Electrical Manufacturers Association NEMA 250 Enclosures for Electrical Equipment (1000 Volt Maximum)

1.3 PERFORMANCE REQUIREMENTS

A. The refrigeration machine system shall include piping within the machine up to and including the flanged connection for chilled-water and condenser-water inlets and outlets; and control equipment and wiring within the machine, including the chilled-water and condenser pressure-differential switches, the unit-mounted variable frequency drive, auxiliary oil-pump starter and control and instrumentation devices specified.

B. Efficiency: Refrigeration machine shall have a full-load (conditions as described in ARI Standard 550-92) operating efficiency of 0.6 kW/ton or less when rated at scheduled operating conditions. Integrated part-load value (IPLV) at various part-load conditions as described in ARI Standard 550-92 shall be 0.56 kW/ton or less.

C. Refrigerant: Refrigeration machine shall use HFC-134a refrigerant.

D. Acoustical Performance:
1. Sound-pressure levels for the complete unit shall not exceed 83 dBA. Provide acoustic treatment as required. Sound data shall be measured in accordance with ARI 575. Data shall be in dB, reference 0.0002 dyne/cm2, measured along a perimeter 1 m from machine and at a height of 1.5 m above floor. Data shall be at the highest levels recorded in three operating positions: 100 percent load, 75 percent load, 50 percent load, and 20 percent load.
2. The maximum permissible noise level shall not exceed 88 dB in each octave band when measured as described in subparagraph 1. above.
3. Chiller fan shall be provided with a fan shroud to lower the sound level further.

E. Compressor assembly vibration shall not exceed 1.0 mil (0.03 mm) at the bearings.

1.4 SUBMITTALS

A. Submit under provisions of Division 23 Section "Common Results for HVAC, Review of Materials and Division 01 Section "General Requirements."

B. Shop Drawings:
1. Drawings of refrigeration machine, including dimensions prior to manufacture.
2. Complete wiring diagrams specifically for the proposed equipment. No typical diagram will be considered. Include required wiring between unit and starter. Indicate locations of conduit connections.

C. Product Data:
1. Refrigeration machine description and data, addressing items to be provided.
2. ARI 550 certified performance curves (kW input vs. output) for full load and non-standard part load value (NPLV). Provide performance data for both ice-making and chilled-water temperature conditions as applicable.
3. Sound-power data by octave band, at 100 percent, 75 percent, 50 percent and 20 percent of full load.
4. Refrigerant gas monitor.

D. Test Data: Certified test report as specified in subpart 2.12, “Source Quality Control.”

PART 2 - PRODUCTS

2.1 AIR-COOLED CHILLERS

A. General:
1. Type: Motor-driven hermetic or open, rotary, scroll or centrifugal water-chilling machine, complete with accessories.

B. Compressor:

1. Each unit shall be equipped with a direct-drive compressor, operating at not more than 35,000 rpm, driven by a squirrel-cage induction motor. Units with speed-increasing gears shall operate between 10,000 and 30,000 rpm.
2. The compressor shaft-and-impeller assembly, and the rotor-shaft [-gear] assembly shall both be statically and dynamically balanced. There shall be no critical speed within the compressor operating range.
3. Select compressor to ensure stable operation at operating points from 15 percent to maximum-rated load at design conditions.
4. Provide a separate feed-lubrication system for each compressor, consisting of an oil tank and oil sump, an immersed positive-displacement, hermetically-sealed, motor-driven pump to provide proper lubrication, and a filter for delivery of clean oil to the bearings. The oil sump shall contain a thermostatic control for maintaining proper oil temperature, to prevent dilution of oil by refrigerant. The oil shall be separately cooled for proper lubrication viscosity before being delivered to the bearings. Factory mount and field wire the oil pump starter to oil pump.
5. The rotor shall be built of noncorrosive material, unaffected by refrigerant contact. Compressor casing construction shall permit removal of rotor shaft. Provide casing joints with gaskets of suitable material to prevent inward and outward leakage.
6. Impellers shall be cast from high-strength aluminum alloy, balanced both statically and dynamically. Impeller shall be proof-tested at least 15 percent above design operation speed.
7. Capacity control shall be by variable inlet guide vanes, automatically controlled, and capable of modulating performance from 15 percent to 100 percent rated unit capacity without surging. Provide single-stage units or three-stage units with inlet vanes in front of only one compression stage.
8. Provide suitable means to prevent entrained liquid from entering the compressor, and uniformly distributing the liquid refrigerant. Provide float-valve housing and float box, ASME BPVC-approved receding-type, spring-loading, relief valve suitable for attachment of relief piping (in accordance with applicable codes) and liquid-level sight gauge. Isolate vent piping from the relief valve with an ASME BPVC-approved isolation device in the piping. Provide braided flexible pipe connections to vent piping. Valve shall vent only enough refrigeration to relieve pressure, not the full refrigeration charge. Install the vent piping in accordance with ASHRAE 15 and ASME BPVC.

C. Evaporator and Condenser:
1. Type: Construct of welded steel, in accordance with ASME BPVC Sec VIII for positive-pressure machines, and design for water circulation quantity scheduled. The total water side pressure drop from inlet to outlet shall not exceed that scheduled.
2. Tubes: Construct of 0.035 inch (9 mm) thick copper, rolled into grooved holes in the tube sheet and removable without affecting the strength or durability of the tube sheet or causing leakage at adjacent tubes. Water velocity in the tubes shall not exceed 10 fps.
3. Tube Sheet: Construct of carbon steel, welded to the shell. Provide sufficient intermediate tube sheets to prevent tube vibration, and space tube supports at no greater interval than 5 feet.
4. End Covers: Provide removable end covers on the condenser tube bundle constructed of high-grade fabricated steel, or other material suitable for the specified pressures. Each separable cover shall be removable so that the complete tube sheet can be exposed for cleaning.
5. Connections: Provide a 1 inch (25 mm) valved drain connection, and a 1 inch (25 mm) vent connection on each water box.
6. Relief Valve: Provide a relief valve to release refrigerant where recommended by the manufacturer.
7. Baffles: Provide suitable baffles to prevent direct impingement of gases upon the tubes, and to distribute the gas uniformly over the length of the condenser. Provide a carbon-steel baffle sheet, to segregate and collect the non condensible gases for purging. Sheet shall be sufficiently thick enough to prevent corrosion of the condenser shell. Include a properly located connection to remove non condensible gases and water vapor through purge and recovery units.

D. Motor:
1. Cable Connection Box: Provide a suitable cable connection box so mounted to provide full access to terminals. The cable connection box shall be capable of accepting the necessary feeder conductors. Size the cable terminals for the full-load current and suitabilities to accept copper conductors without excessive heating.
2. Open-Drive Motor/Compressor: Submit calculations verifying that the ventilation system for the refrigeration machine room will maintain it at 99°F indoor ambient maximum, based on 95°F outdoor ambient ventilation air. Include in the calculations, the heat rejected from motors, condensers, and other inertia base equipment in the refrigeration machine room such as chillers, pumps, fans, compressors, and like equipment.

E. Variable Frequency Drive

1. Unit mounted in a NEMA-4X stainless steel enclosure with padlock provision with power and control wiring between the drive and chiller factory installed or performed in the field by the chiller manufacturer, including power to the chiller oil pump. Field power wiring is a single point connection and electrical lugs for incoming power are provided.
   a. The entire chiller package and variable speed drive shall be UL listed.
   b. PWM drive type utilizes IGBT's.
   c. Total power factor of 0.95 or better, as measured on the feeder side of the harmonic filter, at loads and speeds.
   d. A door interlocked circuit breaker, capable of being padlocked.
   e. UL listed ground fault protection.
   f. Overvoltage and undervoltage protection.
   g. 3 phase sensing motor overcurrent protection.
   h. Single phase protection.
   i. Insensitive to phase rotation.
   j. Overtemperature protection.
   k. Digital readout at the chiller Control Panel includes output frequency; output voltage; 3 phase output; current, input Kilowatts(KW) and Kilowatt hours (KWH); self diagnostic service parameters.
   l. The entire chiller package shall have factory mounted VFD. When VFD s cooled by condenser water, piping to and from the VFD shall be factory installed.
2. The variable speed drive must include a harmonic filter that meets IEEE Standard 519-1992.
   a. The IEEE Std 519-1992 Filter Includes:
      1) A harmonic filter that limits electrical power supply distortion (current and voltage) from the variable speed drive to comply with the guidelines of IEEE std. 519-1992.
      2) The filter is unit mounted within the same NEMA-1 enclosure as the VSD and is UL listed.
      3) Digital readouts provided at the chiller Control Panel as part of the filter package : input KVA; total power factor; 3 phase input voltage; 3 phase input current; 3 phase input voltage total harmonic distortion (THD); 3 phase input current total demand distortion (TDD); self diagnostic service parameters.

2.2 CONTROLS

A. Microprocessor Panel: Provide microprocessor panel for each unit, with individual gauges, and minimum 20-character light-emitting diode (LED) screen indicating purge-condenser drum pressure, high-, low-, and differential-oil pressure, evaporator-refrigerant pressure, condenser refrigerant pressure, evaporator entering and leaving temperatures, condenser entering and leaving temperatures, percent motor current, and operating hours. This panel shall contain switches to permit manual or automatic operation of the oil pump and purge pump; switch to operate purge oil-separator heater and pilot light to indicate its operation; front mounted rocker-switch with separate pilot light providing system energization and refrigeration machine AUTO-OFF control. Provide monitoring of low-evaporator temperature and differential oil-pressure cutouts. The panel shall contain a capacity control mechanism that limits the maximum amperage drawn by the compressor motor, by monitoring motor amperage and the inlet guide vanes.

B. limiter switch shall permit manual control of power demand to 40, 60, 80, and 100 percent of full-load power. Build into the control panel an anti-recycle timer to ensure 30 minute intervals between successive compressor starts. Also include an oil-pump time-delay relay to provide oil-pump operation during compressor coast-down, a time-delay feature to maintain the capacity inlet guide vanes in a closed position during compressor start-up, and meters to indicate the number of compressor starts and total elapsed-running time. Provide a numbered terminal strip for field interlock wiring.

C. Electronic temperature controller shall be capable of maintaining the set-point temperature to within 1°F (0.5°C). It shall have field-adjustable ramp-function loading to permit the rate at which the refrigeration machine is allowed to load from start to full load to be varied between 6 to 24 minutes. Temperature set-point shall be adjustable with a calibrated dial on the front panel.

2.3 INSULATION

A. Insulation: Flexible, elastomeric, closed-cell sheet insulation, 3/4 inch (20 mm) thick, suitable for outdoor installation; with a K factor not exceeding 0.27 at 75 deg F (24 deg C) mean temperature in accordance with

ASTM C 177, and a water-vapor permeability of 0.15 perm-inch or less in accordance with ASTM E 96, procedure B; Armstrong “AP Armaflex,” Rubatex Corp. “R1800FS,” or equal.

B. Adhesive: Armstrong “520,” Rubatex Corp. “R373,” or equal adhesive recommended by the insulation manufacturer for this application.

C. Factory insulate cold surfaces of the refrigeration machine, except uni-shell vessels (cooler/condenser in one shell) shall be insulated in their entirety, including the condenser section.

D. Apply the insulation to the surface with adhesive over the entire surface and seal butt joints with adhesive. Insulation installation shall be in accordance with application recommendations described in the Armstrong pamphlet “Specifications - Installation of Armaflex Insulations,” IP-2268, or comparable manufacturer’s printed installation recommendations.

E. Field insulate areas that show evidence of sweating during operation, using the same materials as the factory insulation.

F. Factory paint insulation and joint material to match refrigeration machine color; Armstrong “WB Armaflex Finish,” Rubatex Corp. “R374,” or equal water-based latex enamel coating for use over insulation provided.

2.4 FACILITIES MONITORING AND CONTROL (FMCS) INTERFACE

A. The chiller control system shall be Johnson Controls Metasys Compatible and provide a single point of interface of the chillers to the facility FMCS. Be responsible for hardware, software required.
   1. The FMCS subcontractor shall wire the FACS to the chiller control panel termination point.

B. The interface shall provide monitoring of information normally available at the chiller control panel, the ability to change manual settings normally made at the chiller control panel, as well as the ability to change settings automatically, such as chilled water temperature reset, demand limiting, etc.

2.5 SOURCE QUALITY CONTROL

A. Notify the University at least 7 days in advance of tests to allow University Representative(s) to witness the tests.

B. Completely assemble the compressor at the factory, and hydrostatically tested either before or after assembly of shaft and rotor. After assembly, pressure-test the compressor with a mixture of refrigerant and air, and test the casing, joints and connections with an electronic refrigerant detector.

C. Conduct performance tests on the refrigeration machine in accordance with ARI 550 at the manufacturer’s factory under 100 percent, 75 percent, 50 percent and 25 percent load conditions to check performance capacity and efficiency, vibration, operating controls, and safety cutouts.

D. Pressure Test Requirements: The cooler waterside shall be hydrostatically tested at 225 psi gauge for a working pressure of 150 psi gauge, and the condenser waterside shall be hydrostatically tested at 225 psi gauge for a working pressure of 150 psi (1 035 kPa) gauge. The refrigerant side shall be tested at 1-1/2 times the working pressure.

E. If the equipment fails to perform within the tolerances set forth in ARI 550, correct the problem and retest at no additional cost to the University. If the machine still fails to perform, the University will reject the refrigeration machine.

F. Submit a certified test report confirming performance as specified.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install chiller package on concrete foundations, sole plates and sub-base. Align, level, grout, and bolt in place.

B. Arrange piping for easy dismantling to permit tube cleaning.

C. Provide auxiliary water piping necessary for oil-cooling units and purge condensers.

D. Refrigerant Piping: Provide refrigerant hot-gas and liquid piping for remote condenser units in accordance with the manufacturer's requirements and the drawings.

E. Provide pressure-relief discharge piping from relief valve to outdoors. Provide stainless-steel flexible connector at the refrigeration machine as detailed on the drawings. Discharge shall be at least 15 feet above grade, and 20 feet away from building opening. Provide size recommended by chiller manufacturer, terminated with gooseneck facing down.

F. If no factory-mounted oil cooler chilled-water-piping circuit is provided, provide field piping in accordance with manufacturing recommendations, including valves, filters and drains.

G. Connect purge-unit discharge piping into main system pressure-relief piping upstream of flexible connector.

H. Before units are started, pump new grease into bearing housing to force out old grease and provide adequate lubrication.

3.2 FIELD QUALITY CONTROL

A. Manufacturer's Field Services:
   1. Provide service of a factory-trained service engineer to supervise testing, evacuation, hydration, charging of unit, and start-up; make necessary adjustments; and instruct the University's operator on the care, operation and maintenance of the system.
   2. Provide five 8-hour days of service for the first unit, and two 8-hour days for each additional unit.

B. Notify the University at least 24 hours in advance of field tests to allow University Representative to witness the tests.

C. Operational Control Tests:
   1. Demonstrate proper functioning of the entire operational control of the chiller. Verify proper operation as specified in part 2 of this section, including oil pumps, liquid-line solenoid valves, crankcase heaters, thermal-expansion valves, chilled-water and condenser water flow switches, and adjustable temperature controllers.
   2. Demonstrate chiller capacity control by varying the chiller load. The capacity range to be tested shall be from no-load to full-load and back to no-load. The chiller shall demonstrate stable operation without excess vibration or noise. Verify each step of the multi-step control (cylinder unloading and/or compressor staging).

D. Safety Control Tests:
   1. Demonstrate proper functioning of safety cutouts in accordance with safety control requirements of part 2 of this section.
   2. Demonstrate that manual resetting is required to restart compressors for safety cutouts.
   3. Demonstrate proper operation of interlocking between chillers and condenser-water pumps, and between chillers and chilled-water pumps.
   4. Simulate variables to activate safety control actions.
   5. All safety control tests shall be verified by electric signals at the compressor motor starters or actual stopping of the compressors.

E. Running and Warning Indicators Test:
   1. Demonstrate proper functioning of indicating lights.
   2. Testing of running and warning indicators may be performed concurrently with safety control tests.

F. Site Tests:

1. Pressure Test: After assembly of the complete unit on the job, pressure test the unit with a mixture of refrigerant and air, and test connections and welds with an electronic leak-detector torch and make refrigerant-tight. The complete unit shall be dehydrated by producing a vacuum to 0.3 inch Hg absolute and maintained for four hours. At the end of this period, stop the pump. The vacuum shall be maintained in the refrigeration unit for a period of 24 hours without gaining more than 0.1 inch Hg absolute pressure.
2. Provide sufficient refrigerant and dry nitrogen for pressure testing under manufacturer's supervision.
3. Provide instruments required for conducting tests.

END OF SECTION 23 64 27

Section 23 82 19 – Fan Coil Units

PART 1 GENERAL

1.1 SUMMARY

.1 Section includes:

.1 Materials and installation for fan coil units.

1.2 REFERENCES

.1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)

.1 ASHRAE 79 – Method of Testing for Rating Fan-Coil Conditioners.

1.3 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

.1 Product data to include:

.1 Filters, fan accessibility.

.2 Suspension, anchoring of cabinet.

.3 Physical size.

.4 Thermostat, transformer, controls where integral.

.5 Finish.

.6 kW rating, voltage, phase.

.7 Cabinet material thicknesses.

.2 Shop Drawings:

.1 Submit shop drawings in accordance with Section 01 33 00 - Submittal Procedures.

.3 Quality assurance submittals: submit following in accordance with Section 01 33 00 - Submittal Procedures.

.1 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.

.2 Instructions: submit manufacturer's installation instructions.

1.4 DELIVERY, STORAGE, AND HANDLING

.1 Packing, shipping, handling and unloading:

.1 Deliver, store and handle in accordance with manufacturer's written instructions and Section 01 61 00 - Common Product Requirements.

PART 2 PRODUCTS

2.1 FAN COIL UNITS

.1 Cabinet: steel, 1.2 mm thick, floor wall or ceiling mounting, recessed. Front inlet/front outlet.

.2 Blower motors: one speed, single phase.

.3 Built-in thermostat with integral relay as indicated. Wall mounted thermostats: type as indicated, to Section 23 09 33 - Electric and Electronic Control System for HVAC.

.4 Fan delay switch.

.5 On-Off switch (for wall mount unit only).

.6 Two position selector switch (for wall mount unit only).

.7 Fresh air duct adapter.

.8 Filter: washable and reusable.

.9 Trim for flush installation.

.10 Finish: three stage phosphatized treatment followed by 2 coats baked enamel with final coat.

.11 Assembly fully wired to one outlet location.

.12 Multiple knockouts for up to 38 mm diam conduit.

PART 3 EXECUTION

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

.1 Mount or hang units as indicated.

.2 Make power and control connections.

3.3 COMMISSIONING

.1 Perform tests in accordance with Section 26 05 00 – Common Work Results - Electrical.

.2 Section 01 91 13 – General Commissioning Requirements.

3.4 CLEANING

.1 Proceed in accordance with Section 01 74 11 - Cleaning.

.2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION 23 82 19

SECTION 255000 – FACILITIES MONITORING AND CONTROL SYSTEM (FMCS)

GENERAL

SUMMARY

A. Related Documents:
   1. Drawings and general provisions of the Subcontract apply to this Section.
   2. Review these documents for coordination with additional requirements and information that apply to work under this Section.

B. Section Includes:
   1. Facilities Monitoring and Control System (FMCS):
      a. Field Processing Units.
      b. Application Specific Controllers
      c. Sensors and control components.
      d. Electronic accessories.
      e. Enclosures.
   2. FMCS communications wiring and components
   3. FMCS Software

RELATED SECTIONS

A. The General Conditions of the Contract, Supplementary Conditions, and General Requirements are part of this specification and shall be used in conjunction with this section as part of the contract documents.

B. The following sections constitute related work:
   1. Division 01
   2. Section 23 05 00 – Common Work Results for HVAC
   3. Section 23 20 23 – HVAC Pumps
   4. Section 23 21 13 – HVAC Piping
   5. Section 23 31 13 – Metal Ducts
   6. Section 23 34 16 – Centrifugal HVAC Fans
   7. Section 23 36 00 – Air Terminal Units
   8. Section 23 40 00 – HVAC Air Cleaning Devices

DESCRIPTION

A. Facilities Monitoring and Control System
   1. The objective of this specification section is to define the work required to install the site-wide, distributed-processing Facilities Monitoring and Control System (FMCS) for control and monitoring of heating, ventilating, air conditioning (HVAC) and process control systems as indicated in the subcontract documents.
   2. The FMCS expansion shall integrate multiple building functions including equipment monitoring and control, alarm management, energy management, historical data collection and archiving, and graphical data display.

3. General: The control system shall consist of a high-speed, peer-to-peer network of DDC controllers and a web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A web server with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
4. The system shall directly control HVAC equipment as specified. Each zone controller shall provide occupied and unoccupied modes of operation by individual zone. Furnish energy conservation features such as optimal start and stop, night setback, request-based logic, and demand level adjustment of setpoints as specified in the sequence.
5. System shall use the BACnet protocol for communication to the operator server and for communication between control modules. I/O points, schedules, setpoints, trends, and alarms shall be BACnet objects.
6. The FMCS shall provide extensive direct digital control (DDC) capabilities for both present and future applications, as well as discrete (on/off) control capabilities. The initial installation shall include DDC temperature control of heating water systems, cooling systems, air handling and air conditioning units, and zone temperature and pressure controls, and discrete start/stop control of fans, pumps, boilers and chillers, as well as selected equipment monitoring functions. The FMCS shall also provide speed control and monitoring of Variable-Frequency Drives (VFDs) specified elsewhere.
7. The FMCS System Operator Workstation software shall include detailed object information files, systems object groups, customized graphics screens, and control routine programming.
8. Provide all labor and materials to install all FMCS software, FMCS hardware, communications hardware and software, enclosures, interconnecting wiring, and all other FMCS components as required to complete the project.
   a. Provide, as available, 120V power from emergency power spare circuits at electrical distribution panels, as well as low voltage power, to all Facilities Monitoring and Control System devices, including but not limited to field processing units, network controllers, application specific controllers, sensors, as, and all components of the FMCS.
9. Provide application specific controllers, actuators, etc. for either factory of field installation on certain equipment, including but not limited to variable and constant volume supply and exhaust air terminal units.
10. Provide connection to certain equipment including determining the type of compatibility and providing all necessary hardware and software to produce compatible connectivity. ALC Compatible connectivity type includes but is not limited to ALC factory mounted controller, BACNET, LON Talk, or 3rd party software. Equipment includes but is not limited to AC units, boilers, humidifiers, variable and constant volume air terminal units, Fan-Filter Powered Units, Laboratory Monitoring and Control System, variable frequency drives and lighting controller. Subcontractor is responsible for verifying the compatibility of 3rd party devices.
11. Be responsible for verifying the FMCS interface for each specified piece of equipment so as to comply with the functional requirements of these specifications. FMCS interface modifications shall be subject to approval by the Engineer.
12. Develop, install, test, tune and prove, and thoroughly document all applications programs.
13. Custom Programming

a. Diagnostic Trend Log Library. Setup a library of pre-defined trend logs as defined by the Commissioning Authority and lab personnel for ongoing evaluation of system operation and troubleshooting. These trends shall be readily accessible to the operator and include user-friendly graphing, viewing, printing and downloading to spreadsheet functions.

b. Smart Alarms. Within 90 days of substantial completion, the Subcontractor shall provide 40 hours of senior staff programming and customization time above all other requirements of this contract for developing with the Engineer and Commissioning Authority, data-acquisition, monitoring, data analysis and manual and automated diagnostics enhancements to the building controls. These diagnostic statements will send messages to a "variance" file or log when parameters exceed prescribed limits. These statements may include such smart alarms as:

   1) In addition to the standard alarm limits specified for all sensed points, FMCS shall provide the following diagnostics for each AHU, AC, and VAV terminal box.
   2) While heating valve is closed, if the temperature increase across the heating coil exceeds 2°F continuously for 30 minutes, or the discharge air temperature is more than 5°F above set point for more than 30 minutes continuously, then send the following level 4 alarm: “Energy waste: An unexpected temperature rise is occurring across the heating coil at (AHU/zone name). Please check for leaking valve or faulty controls”
   3) While cooling valve is closed, if the temperature decrease across the cooling coil exceeds 2F continuously for 30 minutes, or the discharge air temperature is more than 5F below set point for more than 30 minutes continuously, then send the following level 4 alarm: “Energy waste: An unexpected temperature drop is occurring across the cooling coil at (AHU or AC/zone name). Please check for leaking valve or faulty controls”
   4) A level 4 alarm message should be sent if: The mixed air temperature is less than 55F or greater than 80F. Level 4 alarm message is “Energy waste: An unexpected mixed air temperature at (AHU or AC). Indicates a possible problem with the economizer damper controls. Please check for faulty dampers or controls”
   5) A level 4 alarm message should be sent if: The mixed air temperature, discharge air temperature, and the outside air temperature are not equal when the system is operating at 100% outside air and the heating and cooling valve coils have been fully closed for at least two hours (adjustable). Note: Include in comparison the temperature difference caused by fan energy as it relates to discharge air temperature. If differential between sensors is greater than 2.0 Deg.f, then send alarm. Level 4 alarm message is “Mixed air temperature, discharge air temperature, and the outside air temperature are out of calibration at (AHU or AC).”
   6) A level 4 alarm message should be sent if: Any VFD controlled motor operates at full speed for 24 consecutive hours. Level 4 alarm message is “The # motor has operated 24 consecutive hours at full speed. Check software and manual overrides.”
   7) A level 4 alarm message should be sent if: The temperature difference between the refrigerant supply and return is greater than 8°F (set value using manufacturer documentation). Level 4 alarm message is “The

refrigerant charge should be check to help avoid compressor failure or lost efficiency."

B. FMCS Communications
1. The FMCS shall be connected to the System Operator Workstation via the LBNL network to provide remote communications capability for programming, monitoring, manual over-ride, remote alarm indication and logging, and automatic collection and processing of historical data.
   a. It is the responsibility of the subcontractor to ensure that any control systems installed as part of this contract are fully compatible with the existing LBNL FMCS. Any hardware, software or firmware upgrades required for the existing FMCS are the sole responsibility of the controls subcontractor
2. Provide network controller(s) in the main temperature control panel(s) for communication with the System Operator Workstation and Central Server.
3. Provide and install all communications conduit and wiring between building, local and unit controllers.

C. Facility Monitoring and Control System Software
1. Each controller shall be delivered with all application software required to provide a complete and functional control system in accordance with these specifications.
2. System and object naming conventions and control programs shall be developed in a manner consistent with those in the existing system as directed by the Engineer. Naming conventions and examples in Appendix B.
3. Develop, install, test, tune and prove, and thoroughly document all applications programs.

APPROVED CONTROL SYSTEMS

A. Use control system hardware and software that meet the requirements of this specification.

B. Control system shall be Automated Logic Control (ALC) FMCS, no substitutions.

QUALITY ASSURANCE

A. Installer and Manufacturer Qualifications
1. Installer shall have an established working relationship with Control System Manufacturer.
2. Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

CODES AND STANDARDS

A. Work, materials, and equipment shall comply with the most restrictive of local, state, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:
1. National Electric Code (NEC)
2. International Building Code (IBC)
   a. Section 719 Ducts and Air Transfer Openings
   b. Section 907 Fire Alarm and Detection Systems
   c. Section 909 Smoke Control Systems

d. Chapter 28 Mechanical
3. International Mechanical Code (IMC)
4. ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACNET)
5. UL 508A

SYSTEM PERFORMANCE

A. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation as a minimum (server and browser for web-based systems).
1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.
11.

Table 1
Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15ºC (±0.25ºF)
Relative Humidity	±5% RH
Water Flow	±2% of full scale
Airflow (terminal)	±10% of full scale (see Note 1)
Airflow (measuring stations)	±5% of full scale

Airflow (pressurized spaces)	±3% of full scale
Air Pressure (ducts)	±25 Pa (±0.05in. w.g.)
Air Pressure (space)	±3 Pa (±0.005 in. w.g.)
Water Pressure	±2% of full scale (see Note 2)
Electrical (A, V, W, Power Factor)	±1% of reading (see Note 3)
Carbon Monoxide (CO)	±5% of reading
Carbon Dioxide (CO2)	±50 ppm

Note 1: Accuracy applies to 10% - 100% of scale
Note 2: For both absolute and differential pressure
Note 3: Not including utility-supplied meters

Table 2
Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1 in. w.g.)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	
Humidity	±5% RH	
Fluid Pressure	±10 kPa (±1.5 psi) ±250 Pa (±1.0 in. w.g.)	MPa (1-150 psi) 0-12.5 kPa (0-50 in. w.g.) differential

SUBMITTALS

A. Pre-Construction Submittals:
   1. Submit under provisions of Section 013000, General Provisions for all equipment prior to ordering or fabrication. No deviations from the submittals as approved shall be permitted and any materials purchased prior to approval shall be at the sole risk of the Subcontractor.
   2. All submittal data shall be the same size for any group of information, shall be 2-sided whenever possible, and shall be bound or in a three-ring binder as appropriate. All information shall include a Table of Contents and be indexed and tabbed with reference to the specific section of the specification. If catalog cut sheets or published materials include information not applicable to the item furnished, the Subcontractor shall clearly indicate what information is applicable. Indicate all options or accessories to be provided. Indicate part numbers to be ordered with all options.
   3. Administrative Data: Submit name, address and telephone number of the local representative; and a guarantee that the Subcontractor will provide a maximum 24 hour on-site response to trouble calls at any time of day during the warranty period.
   4. Identification and Labeling: Submit a sample of point, hardware, system, terminal, and wiring convention that are in accordance with the Engineer standards. The approved format is to be used on all submittals and field labeling.
   5. Submit the following:
      a. Direct Digital Control System Hardware

1) Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.
2) Manufacturer’s description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:
    a) Direct digital controllers (controller panels)
    b) Transducers and transmitters
    c) Sensors (include accuracy data)
    d) Actuators
    e) Valves
    f) Relays and switches
    g) Control panels
    h) Power supplies
    i) Batteries
    j) Operator interface equipment
    k) Wiring
3) Wiring diagrams and layouts for each control panel. Show termination numbers.
4) Floor plan schematic diagrams indicating field sensor and controller locations.
5) Riser diagrams showing control network layout, communication protocol, and wire types.

b. Central System and Portable Operator’s Terminal Hardware and Software
1) Complete bill of material indicating quantity, manufacturer, model number, and relevant technical data of equipment used.
2) Manufacturer’s description and technical data such as product specifications and installation and maintenance instructions for items listed below and for relevant items furnished under this contract not listed below:
    a) Central Processing Unit (CPU) or web server
    b) Monitors
    c) Keyboards
    d) Power supplies
    e) Battery backups
    f) Interface equipment between CPU or server and control panels
    g) Operating System software
    h) Operator interface software
    i) Color graphic software
    j) Third-party software
3) Schematic diagrams of control, communication, and power wiring for central system installation. Show interface wiring to control system.
4) Network riser diagrams of wiring between central control unit and control panels.

c. Controlled Systems
1) Riser diagrams showing control network layout, communication protocol(s), and wire types.
2) Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
3) Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system schematic, use the same name.

4) Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
5) Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points specified as required to operate the systems. Indicate alarmed and trended points.

d. Description of process, report formats, and checklists to be used in Functional Tests.
e. BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

6. Submit a list of all ALC Compatible devices and systems including a list of “sub-points” available from each device and system. Describe what “sub-point” parameters are available and if they are available for viewing only and capable of being modified from a work station. Indicate which “sub-points” are being “brought forward” as part of the document requirements (and what their functions are) and which ones, if any, are not capable of being “brought forward”. The Engineer shall select which additional “sub-points” are to be “brought forward” and what their functions shall be. Include all “brought forward” “sub-points” in the Point List submittal described below.
7. Shop Drawings: Submit all drawings required for the construction, commissioning, maintaining, and future expansion of the system which are in addition to the subcontract drawings. The Subcontractor shall adequately check each in an orderly and consistent manner. The title block shall bear the names and signatures of the employees who drew, checked, and approved them.

a. All drawings prepared by the Subcontractor shall be developed using the AutoCADTM version 2010 or Visio 2007 computer-aided drafting programs. All drawings shall be a maximum ANSI size D. All notations, dimensions, and lettering shall be no smaller than 1/8" on ’D’ size drawings. Font style shall be Simplex or RomanS. The correct orientation (North arrow) and elevation shall be shown on all plan views
b. The Title Sheet shall include the project name, list of drawing titles, list of abbreviations, and a symbol legend. All abbreviations and symbols used on the drawings shall be included in the list of abbreviations and symbol legend, respectively.
c. The control drawings shall contain graphic schematic depictions of all systems with each component, valves, dampers, actuators, coils, filters, fans, pumps, speed controllers, piping, ducting, etc., and each monitored or control point and sensor, all interlocks to other equipment, and include fan and pump cfm; gpm and horsepower by each element. List the location of remote points off the schematic, like static pressure sensors, outside air sensors, etc.
d. The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
e. Point List shall be in matrix format and shall indicate each monitored or controlled point, device, and software. The Point List shall indicate the type of input or output: Digital In, Digital Out, Analog In, or Analog Out, along with an explanation of the characteristics of each of the inputs and outputs (contact only, pulse, 4-20 ma, third party software, etc.) For ALC Compatible devices and systems, each input or output point shall have a detailed description of what “sub-point” parameters are available and if they are available for viewing only and capable of being modified from a work station. The Point List shall

further identify document-required and Engineer-selected “sub-points” that are “brought forward” to the ALC Control system and what their functions are.

1) Point abbreviation / name (names shall be pre-approved by Engineer)
2) Point type (AI, AO, DI, DO). All setpoints and calculated virtual points will also be listed.
3) System the point is associated with.
4) Point description (includes mention (“monitoring only”) if this point is only a monitoring point and doesn’t “control” anything and/or if it is a “setpoint” and/or calculated point).
5) Display unit.
6) Panel address.
7) Panel ID.
8) Panel location.
9) Reference drawing number from blueprints.
10) Intermediate device information.
11) Field device (temperature sensor, starter, contact, static tip, etc.).
12) Comments column.
13) The Controls Subcontractor shall keep the Commissioning Agent informed of all changes to this list during programming and setup.

f. Elementary wiring diagrams shall show all input/output point wiring and communications wiring tubing required. Show all internal and interconnecting wiring points of termination with all connectors and terminals identified. The physical address for each analog and binary input and output object shall be the same as the order listing developed and displayed in each application specific controller.

g. Room Schedule. A listing of all rooms shall be provided with at least the following information for each room: floor, room number, room name, air hander ID, reference drawing number, air terminal tag, heating and cooling valve tag ID, cold and hot pipe size, K factor, minimum and maximum cfm for both heating and cooling, actuator signal range and type.

h. Valve schedule, including at least: valve tag, system tag (air hander or terminal), service (heating or cooling), quantity, action (2-way, 3-way), fail position, body style, size, close-off pressure, gpm or lb/hr, design Cv, actual Cv, design differential pressure (DP), actual DP, actuator type, control signal range; comments.

i. Electrical panel schedule for panels used on power sources including panel number, items served, circuits used, load per circuit, and statement confirming coordination with electrical.

j. For each built-up air handler damper section, provide damper installation and arrangement drawings depicting,

1) Blade orientation
2) Blade rotation

k. Network architecture drawing showing all controllers, workstations, printers, and other devices in a riser format and including protocols and speeds for all trunks.

l. Provide a set of building floor plans showing the location of all points, controllers, and electrical panels used for power sources. Use the Mechanical CAD drawings and turn the color of all layers to a background shade. Then, show all points with a symbol at the point location and the point name and descriptor next to the point.

m. Sequences of Operation: The submittals of control drawings shall include complete detailed written text narrative sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. Block and graphical programming schematics must be accompanied by full written narratives explaining the step-by-step operation of each block with a clear link between the written text and the graphical block. The sequences of operation will be provided in three places: 1) Individual equipment sequences shall be inset on the equipment schematic page or near it; 2) All sequences for all equipment together in successive pages; 3) All sequences together provided in MS Word format (for use in the Systems Manual). Sequence submittals shall include:

1) An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
2) All interactions and interlocks with other systems.
3) Detailed delineation of control between any packaged controls and the building automation system, listing what points the FMCS monitors only and what FMCS points are control points and are adjustable.
4) Start-up sequences.
5) Warm-up mode sequences.
6) Normal operating mode sequences.
7) Unoccupied mode sequences.
8) Shutdown sequences.
9) Capacity control sequences and equipment staging.
10) Temperature and pressure control: setbacks, setups, resets, etc.
11) Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
12) Effects of power or equipment failure with all standby component functions.
13) Sequences for all alarms and emergency shut downs.
14) Seasonal operational differences and recommendations.
15) Initial and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
16) Time of day schedules.
17) To facilitate referencing in testing procedures, all sequences shall be written in small statements, each with a number for reference. For a given system, numbers will not repeat for different sequence sections, unless the sections are numbered.

8. Submit sample customized graphics. As a minimum provide a sample floor plan, AHU flow diagram, chilled water and hot water systems (where applicable) a zone terminal box and lab pressure control (where applicable) graphics.
9. Product Data: Submit technical product specification sheets for each system component and device which includes all data needed to prove compliance with this specification. Clearly indicate the exact model of each component to be provided.
10. Manufacturer’s Installation Instructions: Submit for all components being provided under this section.

B. Schedules

1. Schedule of work provided within one month of contract award, indicating:
   a. Intended sequence of work items
   b. Start date of each work item
   c. Duration of each work item

d. Planned delivery dates for ordered material and equipment and expected lead times
e. Milestones indicating possible restraints on work by other trades or situations
2. Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

C. Pre-Commissioning Submittals
1. Submit under provisions of Division 01.
2. Operator's and programmer's manuals: Submit for all operating, user, and application software provided including all FMCS and third-party software furnished.
3. Project-Specific Submittals: Submit a representative sample of each of the following prior to development of each for the entire project. Once the Engineer's approval has been obtained for the representative sample, provide complete submittals for the entire project.
a. Systems Object Groups: Include printouts of all Systems Object Groups developed for this project.
b. Input/Output Object Testing: Include copies of all Testing Documentation Forms to be completed for this project recording at a minimum (as applicable): hardware address, object name, device type, transmitter type, signal range, signal formula, and readout formula.
c. Software Documentation: Submit input/output point name definitions, data object name definitions, a complete listing of control routine file names, a printout of each control routine, an English-language textual description of each control routine's function, and a printout of each system grouping and graphic display for this project.
d. Sequence of Operation Testing: Submit a copy of the Sequence of Operation annotated with the Subcontractor's testing methods proposed to be performed to prove compliance with the specification.

D. Project Record Documents. Submit under the provisions of Section 013000 (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:
1. Project Record Drawings. As-built versions of submittal shop drawings provided as editable AutoCAD 2010 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, . or comparable) and 6 prints of each drawing on 11" x 17" paper. All record drawings will be placed on the LBNL background, supplied by LBNL. Visio drawings are not acceptable for record drawings.
2. Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs.
3. Operation and Maintenance (O&M) Manual. Printed (3 copies), and one electronic in CD Rom of the following:
a. As-built versions of submittal product data.
b. Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
c. Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
d. Programming manual or set of manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

e. Engineering, installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
f. Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
g. Graphic files, programs, and database on magnetic or optical media.
h. List of recommended spare parts with part numbers and suppliers.
i. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
j. Complete licensed, original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
k. Licenses, guarantees, and warranty documents for equipment and systems.
l. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
m. Full as-built set of control drawings and sequence of operations.
n. Marking of all systems sensors and thermostats on the as-built floor plan and mechanical drawings with their control system designation.
o. Full print out of all schedules and setpoints after testing and acceptance of system.
p. Control equipment component submittals, parts lists, etc.
q. Warranty requirements.
r. Copies of all checkout tests and calibrations performed by the Subcontractor (not commissioning tests).
s. The manual shall be organized and subdivided with permanently labeled tabs for each of the following data in the given order:
  1) Sequence of operation
  2) Control drawings
  3) Points lists
  4) Controller / module data
  5) Thermostats and timers
  6) Sensors and DP switches
  7) Valves and valve actuators
  8) Dampers and damper actuators
  9) Program setups (software program printouts)

E. Documentation of Changes During Warranty Period
1. During the warranty period, all copies of the drawings and manuals shall be updated to include all hardware and software changes which were required to solve problems covered by the warranty.

F. Training Materials: Provide course outline and materials for each class at least two weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Engineer will modify course outlines and materials if necessary to meet Engineer’s needs. Engineer will review and approve course outlines and materials at least three weeks before first class. Contractor shall provide 4 hours of training per system (AHU,ACHW, HW, BLR etc)

QUALITY ASSURANCE

A. Service: The Subcontractor shall have a service office which has been established for a minimum of five years and is staffed with factory-authorized service technicians capable of servicing all aspects of the FMCS. This office shall have an emergency service available and shall provide a maximum 24 hour on-site response to trouble calls at any time of day.

B. UL/ETL: All new FMCS components shall be listed as suitable for the purpose specified and shown on the drawings by Underwriters Laboratory (UL), Electronic Testing Laboratories (ETL), or other nationally-recognized testing service certified for testing in accordance with UL standards, wherever such products are available.

C. Qualification of the HVAC Controls Manufacturer and Lead Installing Technician
   1. Provide a list of four projects which the vendor has installed that are similar in size and complexity to this contract, with the name and telephone number of the contracting officer and facility administrator, size of project, location and brief description and date of completion.
   2. Lead Programmer/Engineer (LP): The majority of programming for this project will be completed by the lead programmer. The LP will personally review and approve all programming by others. Within 30 days after notice to proceed, the control contractor shall submit the following regarding the LP: name, certification training on this system; list of two projects of similar size and complexity to this contract which were primarily programmed by the LP; and for each project the project name, location, description, cost, name and telephone number of the contracting officer and current facility administrator and date of completion. A replacement to the LP must be approved in wiring by the Engineer.
   3. Lead Installation Technician (LIT): The automatic controls will be installed under the direct and continuous supervision of a lead technician authorized by the manufacturer. Within 14 days after notice to proceed, the controls, contractor shall submit the following regarding the LIT: name; certification of training on this system; list of two projects of similar size and complexity to this contract which were directly supervised by the LIT; and for each project the project name, location, description, cost, name and telephone number of the contracting officer and current facility administrator ad date of completion. A replacement to the LIT must be approved in writing by the Engineer.
   4. Acceptance: A review of the qualifications and action upon the acceptance of the manufacturer and the LIT and LP will be completed by the Engineer. If the manufacturer, the proposed product line or the qualifications of the LIT or LP are not in accordance with the Contract Documents or, in the opinion of the Engineer will not result in a satisfactory completed product, alternatives must be submitted for approval.

DELIVERY, STORAGE AND HANDLING

A. Care should be taken to prevent damage to materials and equipment during loading, transporting and unloading. Equipment shall be delivered in their original packaging. Equipment and materials shall be stored inside or protected from the weather.

WARRANTY

A. Warrant work as follows:

1. Warrant labor and materials for specified control system free from defects for a period of 12 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to Engineer. Respond during normal business hours within 24 hours of Engineer’s warranty service request.
2. Work shall have a single warranty date, even if Engineer receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.
3. If Engineer determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Engineer will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.
4. Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Subcontractor-identified software deficiencies at no charge during warranty period. If available, Engineer can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Engineer’s written authorization.
5. Exception: Subcontractor shall not be required to warrant reused devices except those that have been rebuilt or repaired. Installation labor and materials shall be warranted. Demonstrate operable condition of reused devices at time of Engineer’s acceptance.

ENGINEER OWNERSHIP OF PROPRIETARY MATERIAL

A. Project-specific software and documentation shall become Engineer’s property. This includes, but is not limited to:
   1. Graphics
   2. Record drawings
   3. Database
   4. Application programming code
   5. Documentation

PRODUCTS

MATERIALS

B. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by Engineer. Spare parts shall be available for at least five years after completion of this contract.

COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.
1. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.
2. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

E. Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

F. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

SYSTEM OPERATOR INTERFACE

A. Operator Interface. Server shall reside on LBNL’s network with building controllers. Each standard browser connected to server shall be able to access all system information. Any computer running Internet Explorer 6 or greater shall be able to access the system through the server.

B. Communication. Server or workstation and controllers shall communicate using BACnet protocol. Server and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135-2004, BACnet Annex J.

C. Hardware. Each system server shall consist of the following:
1. Hardware Base. Industry-standard hardware shall meet or exceed DDC system manufacturer’s recommended specifications. Hard disk shall have sufficient memory to store system software, 3 years of data for trended points and a system database at least twice the size of the existing database at system acceptance. Configure computers and network connections if multiple computers are required to meet specified memory and performance. Server or workstations shall be IBM-compatible PCs with a minimum of:
a. Intel Quad Core 3 GHz processor
b. 16 GB RAM
c. 500 GB hard disk providing data at 100 MB/sec
d. 48x CD-RW/DVD drive with Roxio Digital Media and Cyberlink Power DVD.
e. 20 inch wide screen flat panel display.
f. 256 MB NVIDIA Quadro NVS 100M Turbocache graphics card.
g. Integrated audio card.
h. Full function keyboard.
i. External speakers.

j. 4 USB ports.
k. Optical mouse.
l. 3 Year Limited Warranty plus 3 year NBD On-Site Service.
m. Serial, parallel, and network communication ports and cables required for proper system operation

D. Operator Functions. Operator interface shall allow each authorized operator to execute the following functions as a minimum:
1. Log In and Log Out. System shall require user name and password to log in to operator interface.
2. Point-and-click Navigation. Operator interface shall be graphically based and shall allow operators to access graphics for equipment and geographic areas using point-and-click navigation.
3. View and Adjust Equipment Properties. Operators shall be able to view controlled equipment status and to adjust operating parameters such as setpoints, PID gains, on and off controls, and sensor calibration.
4. View and Adjust Operating Schedules. Operators shall be able to view and adjust scheduled operating hours of each individual, schedulable piece of equipment on a weekly or monthly calendar-based graphical schedule display, to select and adjust each schedule and time period, and to simultaneously schedule related equipment. System shall clearly show exception schedules and holidays on the schedule display.
5. View and Respond to Alarms. Operators shall be able to view a list of currently active system alarms, to acknowledge each alarm, and to clear (delete) unneeded alarms.
6. View and Configure Trends. Operators shall be able to view a trend graph of each trended point and to edit graph configuration to display a specific time period or data range. Operator shall be able to create custom trend graphs to display on the same page data from multiple trended points.
7. View and Configure Reports. Operators shall be able to run preconfigured reports, to view report results, and to customize report configuration to show data of interest.
8. Manage Control System Hardware. Operators shall be able to view controller status, to restart (reboot) each controller, and to download new control software to each controller.
9. Manage Operator Access. Typically, only a few operators are authorized to manage operator access. Authorized operators shall be able to view a list of operators with system access and of functions they can perform while logged in. Operators shall be able to add operators, to delete operators, and to edit operator function authorization. Operator shall be able to authorize each operator function separately.

E. System Software.
1. Operating System. Web server shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Windows Server .
2. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.
a. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

b. Animation. Graphics shall be able to animate by displaying different image files for changed object status.
c. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
d. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Any plug-ins required shall only require widely available no-cost plug-ins (such as Active-X, JavaScript and Macromedia Flash).

3. Include and install Microsoft SQL Server 2008 for support of the system. This will be incorporated into the server running the FMCS application for management of the automation system.
4. All authentication to the system shall be encrypted. A commercial certificate shall be used for SSL communication.

F. System Tools. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

1. Automatic System Database Configuration. The web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.
2. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.
3. System Configuration. Operators shall be able to configure the system.
4. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.
5. Security. System shall require a user name and password to view, edit, add, or delete data.
   a. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object. Authorized operators shall be able to vary and deny each operator’s accessible functions based on equipment or geographic location.
   b. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.
   c. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.
6. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).
7. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

8. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.
9. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.
10. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.
11. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk. Configure trends as specified in Commissioning Plan.
12. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.
13. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.
14. Standard Reports. Furnish the following standard system reports:
    a. Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.
    b. Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.
    c. Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:
        1) Alarm History.
        2) Trend Data. Operator shall be able to select trends to be logged.
        3) Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.
15. Custom Reports. Operator shall be able to create custom reports that retrieve data, including archived trend data, from the system, that analyze data using common algebraic calculations, and that present results in tabular or graphical format. Reports shall be launched from the operator interface.
16. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and binary values, dynamic text, static text, and animation files to a background graphic using a mouse.
17. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.
18. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

a. Language. Language shall be graphically based and shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks.

b. Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

c. Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

d. Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

e. Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

f. Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

g. Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

1) Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

2) System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

G. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting. Laptop shall meet the minimum requirements:

1. Intel Duo Core T2400 (1.83 GHz) 667 MHz Dual Core processor.
2. Windows XP Professional Service Pack 2 operating system.
3. 15.4 inch Wide Screen WXGA LCD panel.
4. Keyboard.
5. 256 MB NVIDIA Quadro NVS 100 TurboCache graphics card.
6. 2.0 GB, DDR2-667 SDRAM, 2 DIMMS memory.
7. 120 GB, 9.5 mm, 5400 RPM hard drive.
8. Intel 3945 802.11a/g Dual-Band Mini Card wireless LAN.
9. 8x DVD +/-RW w/Roxio Digital Media and Cyberlink Power DVD.
10. 9-cell primary battery.

11. Backpack carrying case.
12. 90 watt AC power adapter.
13. Technical support – 3 years.
14. 3 Year Limited Warranty plus 3 year On-Site Service.

H. BACnet. Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in ASHRAE/ANSI 135-2001, BACnet Annex L.

CONTROLLER SOFTWARE

A. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation, web browser interface, or engineering workstation.

B. System Security. See Paragraph 2.3.F.5 (Security).

C. Scheduling. See Paragraph 2.3.D.4 (View and Adjust Operating Schedules). System shall provide the following schedule options as a minimum:
1. Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).
2. Exception. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.
3. Holiday. Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

D. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

E. Binary and Analog Alarms. See Paragraph 2.3.F.7 (Alarm Processing).

F. Alarm Reporting. See Paragraph 2.3.F.9 (Alarm Reactions).

G. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms.

H. Demand Limiting.
1. System shall monitor building power consumption from building power meter pulse generator signals or from building feeder line watt transducer or current transformer.
2. When power consumption exceeds adjustable levels, system shall automatically adjust setpoints, de-energize low-priority equipment, and take other programmatic actions to reduce demand. When demand drops below adjustable levels, system shall restore loads as specified.

I. Maintenance Management. System shall generate maintenance alarms when equipment exceeds adjustable runtime, equipment starts, or performance limits. Configure and enable maintenance alarms as specified.

J. Sequencing. Application software shall sequence chillers, boilers, and pumps as specified in Mechanical Specifications and Drawings.

K. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

L. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

M. Energy Calculations.
   1. System shall accumulate and convert instantaneous power (kW) or flow rates (L/s [gpm]) to energy usage data.
   2. System shall calculate a sliding-window average (rolling average). Operator shall be able to adjust window interval to 15 minutes, 30 minutes, or 60 minutes.

N. Anti-Short Cycling. Binary output objects shall be protected from short cycling by means of adjustable minimum on-time and off-time settings.

O. On and Off Control with Differential. System shall provide direct- and reverse-acting on and off algorithms with adjustable differential to cycle a binary output based on a controlled variable and setpoint.

P. Runtime Totalization. System shall provide an algorithm that can totalize runtime for each binary input and output. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit. Configure and enable runtime totalization and alarms as specified.

CONTROLLERS

A. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard BACnet Device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L. Unless otherwise specified, hardwired actuators and sensors may be used in lieu of BACnet Smart Actuators and Smart Sensors.

B. BACnet.
   1. Building Controllers (BCs). Each BC shall conform to BACnet Building Controller (B-BC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-BC in the BACnet Testing Laboratories (BTL) Product Listing.
   2. Advanced Application Controllers (AACs). Each AAC shall conform to BACnet Advanced Application Controller (B-AAC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-AAC in the BACnet Testing Laboratories (BTL) Product Listing.
   3. Application Specific Controllers (ASCs). Each ASC shall conform to BACnet Application Specific Controller (B-ASC) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-ASC in the BACnet Testing Laboratories (BTL) Product Listing.
   4. Smart Actuators (SAs). Each SA shall conform to BACnet Smart Actuator (B-SA) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SA in the BACnet Testing Laboratories (BTL) Product Listing.

5. Smart Sensors (SSs). Each SS shall conform to BACnet Smart Sensor (B-SS) device profile as specified in ANSI/ASHRAE 135-2004, BACnet Annex L and shall be listed as a certified B-SS in the BACnet Testing Laboratories (BTL) Product Listing.
6. BACnet Communication.
   a. Each BC shall reside on or be connected to a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing.
   b. BACnet routing shall be performed by BCs or other BACnet device routers as necessary to connect BCs to networks of AACs and ASCs.
   c. Each AAC shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   d. Each ASC shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   e. Each SA shall reside on a BACnet network using the ARCNET or MS/TP Data Link/Physical layer protocol.
   f. Each SS shall reside on a BACnet network using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol with BACnet/IP addressing, or it shall reside on a BACnet network using ARCNET or MS/TP Data Link/Physical layer protocol.

C. Communication.
1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator’s Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.
2. Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.
3. Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.
4. Stand-Alone Operation. Each piece of equipment shall be controlled by a single controller to provide stand-alone control in the event of communication failure. All I/O points specified for a piece of equipment shall be integral to its controller. Provide stable and reliable stand-alone control using default values or other method for values normally read over the network.

D. Environment. Controller hardware shall be suitable for anticipated ambient conditions.
1. Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).
2. Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

E. Keypad. Provide a local keypad and display for each BC and AAC. Operator shall be able to use keypad to view and edit data. Keypad and display shall require password to prevent unauthorized use. If the manufacturer does not normally provide a keypad and display for each BC and AAC, provide the software and any interface cabling needed to use a laptop computer as a Portable Operator’s Terminal for the system.

F. Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

G. Serviceability.
1. Controllers shall have diagnostic LEDs for power, communication, and processor.

2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.
3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

H. Memory.
1. Controller memory shall support operating system, database, and programming requirements.
2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.
3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

I. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

J. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

INPUT AND OUTPUT INTERFACE

A. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

B. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

C. Binary Inputs. Binary inputs shall monitor the on and off signal from a remote device. Binary inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Binary inputs shall sense dry contact closure without application of power external to the controller.

D. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to binary input requirements and shall accumulate up to 10 pulses per second.

E. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

F. Binary Outputs. Binary outputs shall send an on-or-off signal for on and off control. Building Controller binary outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

G. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

H. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated binary outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

I. Universal Inputs and Outputs. Inputs and outputs that can be designated as either binary or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

POWER SUPPLIES AND LINE FILTERING

A. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
   1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.
      a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.
      b. Line voltage units shall be UL recognized and CSA listed.

B. Power Line Filtering.
   1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:
      a. Dielectric strength of 1000 V minimum
      b. Response time of 10 nanoseconds or less
      c. Transverse mode noise attenuation of 65 dB or greater
      d. Common mode noise attenuation of 150 dB or greater at 40-100 Hz

AUXILIARY CONTROL DEVICES

A. Motorized Control Dampers.
   1. Type. Control dampers shall have linear flow characteristics and shall be parallel- or opposed-blade type as specified below or as scheduled on drawings.
      a. Outdoor and return air mixing dampers and face-and-bypass dampers shall be parallel-blade and shall direct airstreams toward each other.
      b. Other modulating dampers shall be opposed-blade.
      c. Two-position shutoff dampers shall be parallel- or opposed-blade with blade and side seals.
   2. Frame. Damper frames shall be 2.38 mm (13 gauge) galvanized steel channel or 3.175 mm (1/8 in.) extruded aluminum with reinforced corner bracing.
   3. Blades. Damper blades shall not exceed 20 cm (8 in.) in width or 125 cm (48 in.) in length. Blades shall be suitable for medium velocity (10 m/s [2000 fpm]) performance. Blades shall be not less than 1.5875 mm (16 gauge).

4. Shaft Bearings. Damper shaft bearings shall be as recommended by manufacturer for application, oil impregnated sintered bronze, or better.
5. Seals. Blade edges and frame top and bottom shall have replaceable seals of butyl rubber or neoprene. Side seals shall be spring-loaded stainless steel. Blade seals shall leak no more than 50 L/s·m2 (10 cfm per ft2) at 1000 Pa (4 in. w.g.) differential pressure. Blades shall be airfoil type suitable for wide-open face velocity of 7.5 m/s (1500 fpm).
6. Sections. Damper sections shall not exceed 125 cm - 150 cm (48 in. - 60 in.). Each section shall have at least one damper actuator.
7. Linkages. Dampers shall have exposed linkages.

B. Electric Damper and Valve Actuators.
1. Stall Protection. Mechanical or electronic stall protection shall prevent actuator damage throughout the actuator’s rotation.
2. Spring-return Mechanism. Actuators used for power-failure and safety applications shall have an internal mechanical spring-return mechanism or an uninterruptible power supply (UPS).
3. Signal and Range. Proportional actuators shall accept a 0-10 Vdc or a 0-20 mA control signal and shall have a 2-10 Vdc or 4-20 mA operating range. (Floating motor actuators may be substituted for proportional actuators in terminal unit applications as described in paragraph 2.6H.)
4. Wiring. 24 Vac and 24 Vdc actuators shall operate on Class 2 wiring.
5. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.

C. Control Valves.
1. General. Select body and trim materials in accordance with manufacturer’s recommendations for design conditions and service shown.
2. Type. Provide two- or three-way control valves for two-position or modulating service as shown.
3. Water Valves.
   a. Valves providing two-position service shall be quick opening. Two-way valves shall have ball
   b. Close-off (Differential) Pressure Rating. Valve actuator and trim shall provide the following minimum close-off pressure ratings.
      1) Two-way: 150% of total system (pump) head.
      2) Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.
   c. Ports. Valves providing modulating service shall have equal percentage ports.
   d. Sizing.
      1) Two-position service: line size.
      2) Two-way modulating service: select pressure drop equal to the greatest of twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply and return mains, or 35 kPa (5 psi).
      3) Three-way modulating service: select pressure drop equal to the smaller of twice the pressure drop through the coil exchanger (load) or 35 kPa (5 psi).
   e. Fail Position. Water valves shall fail normally open or closed as follows unless otherwise specified.
      1) Reheat water zone valves: normally closed.

2) Heating coils in air handlers: normally open.
3) Chilled water control valves: normally closed.
4) Other applications: as scheduled or as required by sequences of operation.

4. Electric Actuators: Manufacturer shall be Belimo. This item is proprietary to match existing LBNL standard and no substitutions will be allowed.

D. Binary Temperature Devices.
1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 13°C-30°C (55°F-85°F) setpoint range, 1°C (2°F) maximum differential, and vented ABS plastic cover.
3. Low-Limit Thermostats. Low-limit airstream thermostats shall be UL listed, vapor pressure type. Element shall be at least 6 m (20 ft) long. Element shall sense temperature in each 30 cm (1 ft) section and shall respond to lowest sensed temperature. Low-limit thermostat shall be manual reset only.

E. Temperature Sensors.
1. Type. Temperature sensors shall be Resistance Temperature Device (RTD) or thermistor.
2. Duct Sensors. Duct sensors shall be single point or averaging as shown. Averaging sensors shall be a minimum of 1.5 m (5 ft) in length per 1 m 2(10 ft 2) of duct cross-section.
   a. Any terminal box equipped with a reheat coil shall have a single-point Supply Air Temperature duct sensor mounted approximately 3 ft. downstream from the coil.
3. Immersion Sensors. Provide immersion sensors with a separable stainless steel well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities.
4. Space Sensors. Space sensors shall have setpoint adjustment, override switch, display, and communication port as shown.
5. Differential Sensors. Provide matched sensors for differential temperature measurement.

F. Humidity Sensors.
1. Duct and room sensors shall have a sensing range of 20%-80%.
2. Duct sensors shall have a sampling chamber.
3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of (40°F-140°F).4.4°C-60°C
4. Humidity sensors shall not drift more than 1% of full scale annually.

G. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.

2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

H. Relays.
1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED "energized" indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable ±100% from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

I. Override Timers.

J. Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6 hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

K. Current Transmitters.
1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

L. Current Transformers.
1. AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

M. Voltage Transmitters.
1. AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.
2. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.
3. Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

N. Voltage Transformers.
1. AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.
2. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

O. Power Monitors.
1. Power monitors shall be three-phase type and shall have three-phase disconnect and shorting switch assembly, UL listed voltage transformers, and UL listed split-core current transformers.
2. Power monitors shall provide selectable output: rate pulse for kWh reading or 4-20 mA for kW reading. Power monitors shall operate with 5 A current inputs and maximum error of ±2% at 1.0 power factor or ±2.5% at 0.5 power factor.

P. Current Switches.
1. Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

Q. Current Sensors
1. Current sensors (CTs) for input directly into the FMCS shall deliver a 4-20 milliampere or 0-5VDC signal proportional to the rated input range. Insulation shall be minimum 10 KV BIL for 600 volt class devices. Accuracy shall be + 0.5%.

R. Pressure Transducers.
1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 1000 kPa (150 psi). Over-range limit (differential pressure) and maximum static pressure shall be 2000 kPa (300 psi.) Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.
5. Differential pressure sensors/transducers shall be solid-state, strain-gage, variable capacitance, or variable reluctance with 4-20 milliamperes output. Accuracy shall be + 1% of calibrated range, the zero and span shall be adjustable, over pressure protection shall be a minimum 150% of rated maximum pressure, and range selected for no more than 50% greater than the expected maximum operating differential pressure.
6. Differential pressure sensors/transducers for reading differential in applications where either leg may be high pressure (e.g. labs with respect to corridors) shall be compound sensors, capable of reading positive or negative differentials, with zero differential at mid-span. Transducers shall meet all other requirements of paragraph A above.
7. Building static pressure sensors/transducers shall be very low differential type with temperature compensation, zero and span adjustments, scale range 0.0 to maximum 1500 kPa (0.0 to 6.0 inch wg) positive or negative, and sensitivity of 6.25 kPa (0.025 inch wg) maximum. Transducers shall meet all other requirements of paragraph A above.

S. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

T. Pressure-Electric (PE) Switches. PE switches shall be UL listed, pilot duty rated (125 VA minimum) or motor control rated, metal or neoprene diaphragm actuated, operating pressure rated for 0-175 kPa (0-25 psig), with calibrated scale minimum setpoint range of 14-125 kPa (2-18 psig).

1. Provide one- or two-stage switch action (SPDT, DPST, or DPDT) as required by application.
2. Switches shall be open type (panel-mounted). Exception: Switches shall be enclosed type for remote installation. Enclosed type shall be NEMA 1 unless otherwise specified.
3. Each pneumatic signal line to PE switches shall have permanent indicating gauge.

U. Liquid Flow Meters

1. General Requirements
   a. Sensor shall be a magnetic flow meter, which utilizes Faraday's Law to measure volumetric fluid flow through a pipe. The flow meter shall consist of 2 elements, the sensor and the electronics. The sensor shall generate a measuring signal proportional to the flow velocity in the pipe. The electronics shall convert this EMF into a standard current output.
   b. Electronic replacement shall not affect meter accuracy (electronic units are not matched with specific sensors).
   c. Provide a four-wire, externally powered, magnetic type flow transmitter with adjustable span and zero, integrally mounted to flow tube. Output signal shall be a digital pulse proportional to the flow rate (to provide maximum accuracy and to handle abrupt changes in flow). Standard 4-20 mA or 0-10 Vdc outputs may be used on HVAC applications provided accuracy is as specified.
   d. Power Source
      1) 24VAC or 24VDC
      2) 120V power source not acceptable.
   e. Flow tube
      1) ANSI class 150 psig steel
      2) ANSI flanges
   f. Lined with
      1) Heating hot water: PTFE, PFA, or ETFE liner rated for 210ºF minimum fluid temperature
      2) Chilled, condenser, domestic hot and cold water: Polypropylene, Ebonite PTFE, PFA, or ETFE liner rated for 140ºF minimum fluid temperature
   g. Electrode and grounding material
      1) 316L Stainless steel or Hastelloy C
      2) Electrodes shall be fused to ceramic liner and not require o-rings.
   h. Electrical Enclosure: NEMA 4 (outdoors), NEMA 1 (indoors)
   i. Approvals
      1) UL or CSA
      2) NSF Drinking Water approval for domestic water applications
   j. Performance
      1) Accuracy shall be ±0.5% of actual reading from 3 to 30 feet per second flow velocities, and ±0.015 fps from 0.04 fps to 3 fps.
      2) Stability: 0.1% of rate over six months.
      3) Meter repeatability shall be ± 0.1% of rate at velocities > 3 feet per second.
   k. Calibration: The sensor must be factory calibrated on an internationally accredited (such as NAMAS) water flow rig with accuracy better than 0.1%. Calibration shall be NIST traceable.
   l. Output

1) Output signal for hardwired connection, one of the following
2) 4-20mA analog output
3) Configurable 4-20 / pulsed output

m. Manufacturers
1) Siemens/Danfoss Magflo 3100
2) Krohne Optiflux 4000
3) Sparling Tigermag EP FM656
4) Onicon F-3000 series
5) Or equal

V. CO2 Sensors

1. For use to measure return air or room CO2 concentration. Unit shall be suitable for return duct application, have 0-2000 or 0-5000 ppm selectable ranges, and have an output signal suitable for use by the Facilities Monitoring and Control System. Provide necessary power/power supply needed by the sensor.
   a. Provide necessary pre-mixed concentrations of calibration gases for calibration and testing of control and alarm points. Also, provide the gases for use in the commissioning process.

W. Two Position Butterfly Valves

1. Butterfly Valve: Comply with Specification Section 23 21 13, Part 2.6.
2. Electric Actuators: Actuator shall be powered by a 4,600 in-lb. torque, integral, single phase, 120V/60HZ reversible, overload protected motor. The actuator shall have a manual override such that the valve cannot be operated electrically while in the override mode. Gears and shafts shall be manufactured of heat treated, high alloy steel. Actuator shall have a visual output shaft position indicator. Actuator shall have two SPDT adjustable end switches. Manufacturer shall be True Torq Model 800, Bray Series 71, Worcester, or Grinnell, or equal. Neptronics are specifically unacceptable.

X. Air Flow Measuring Stations

1. Fan Inlet Airflow Measuring Station
   a. Manufacturer: Paragon FE-1050, Air Monitor, Tek-Air or equal for fan inlet installation.
   b. The air flow measuring elements shall be constructed of Type 316L stainless steel, forming two (2) integral chambers for total and static pressure averaging, without the physical presence of forward projecting sensors.
   c. The airflow elements shall not induce a pressure drop greater than 0.03 inches water column at 2000 FPM, nor shall the sound level within the duct be amplified by its presence in the airstream. Each airflow measuring element shall contain multiple total and static pressure sensors. The airflow elements shall be capable of producing steady, non-pulsing signals, with an accuracy within +/- 2 percent of actual flow.
   d. Each airflow measuring element assembly shall be complete with all necessary pivot mounting hardwired and signal connection fittings for connection to tubing provided by the installing contractor.
   e. An identification label shall be placed on each element listing the model no., system served, size, and identifying tag number.
2. Duct Airflow Measuring Station

a. Manufacturer: Paragon FE-1500, Air Monitor, Tek-Air or equal for duct installation.
b. The air flow measuring elements shall be constructed of type 304 stainless steel, forming two (2) integral chambers for total and static pressure averaging, without the physical presence of forward projecting sensors.
c. The airflow elements shall not induce a pressure drop greater than 0.03 inches water column at 2000 FPM, nor shall the sound level within the duct be amplified by its presence in the airstream. Each airflow measuring element shall contain multiple total and static pressure sensors. The airflow elements shall be capable of producing steady, non-pulsing signals, with an accuracy within +/- 2 percent of actual flow.
d. Each airflow measuring element assembly shall be complete with all necessary pivot mounting hardwired and signal connection fittings for connection to tubing.
e. An identification label shall be placed on each element listing the model no., system served, size, and identifying tag number.

3. Air Volume Velocity Transmitter
   a. Paragon FT-1000, Air Monitor, Tek-Air, or equal combination differential pressure transmitter, square root extractor and scaling relay.
   b. Transmitters shall be capable of receiving pneumatic signals from their respective primary measuring elements and producing an electronic output signal linear to system static pressure and/or velocity pressure. Transmitter performance shall be as follows:
      1) Span: Not greater than twice that of the system design or three times design for space pressurization control.
      2) Accuracy: +/- 1 percent of span
      3) Hysteresis and Dead Band: Non-Detectable
      4) Linearity: + 1 percent of span
      5) Repeatability: Within 0.2 percent of output
      6) Response: Less than 0.5 seconds for full span input
      7) Temperature Effects: Less than +0.03 percent FS/degreeF
      8) Overpressure: 8 times full scale
   c. Square root extractors shall be capable of receiving and electronic input, linear to velocity pressure, and conditioning this signal to produce an electronic output signal linear to velocity/CFM. The performance shall be as follows:
      1) Accuracy: +/- 0.2 percent of span
      2) Hysteresis and Dead Band: Within 0.01 percent of span
      3) Linearity: + 0.2 percent of span
      4) Repeatability: Within 0.01 percent of output
      5) Response: Less than 0.5 seconds for full span input
   d. Scaling relays shall be capable of receiving a 0-5 VDC input signal and conditioning this signal to produce and electronic output signal (i.e., 0-20 mA) linear to the input. The performance shall be as follows:
      1) Accuracy: +/- 0.1 percent of span
      2) Hysteresis and Dead Band: Within 0.01 percent of span
      3) Linearity: + 0.1 percent of span
      4) Repeatability: Within 0.01 percent of output
      5) Response: Less than 0.5 seconds for full span input

Y. Local Control Panels.

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.
2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

WIRING AND RACEWAYS

A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.

B. Insulated wire shall use copper conductors and shall be UL listed for 90°C (200°F) minimum service.

FIBER OPTIC CABLE SYSTEM

A. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

B. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

EXECUTION
EXAMINATION

C. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Engineer or Engineer for resolution before starting rough-in work.

D. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Engineer for resolution before starting rough-in work.

E. Examine drawings and specifications for work of others. Report inadequate headroom or space conditions or other discrepancies to Engineer and obtain written instructions for changes necessary to accommodate work of others. Controls Subcontractor shall perform at his expense necessary changes in specified work caused by failure or neglect to report discrepancies.

PROTECTION

A. Controls Subcontractor shall protect against and be liable for damage to work and to material caused by Subcontractor’s work or employees.

B. Controls Subcontractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

COORDINATION

A. Site.
   1. Assist in coordinating space conditions to accommodate the work of each trade where work will be installed near or will interfere with work of other trades. If installation without coordination causes interference with work of other trades, Subcontractor shall correct conditions without extra charge.
   2. Coordinate and schedule work with other work in the same area and with work dependent upon other work to facilitate mutual progress.

B. Test and Balance.
   1. Provide Test and Balance Subcontractor a single set of necessary tools to interface to control system for testing and balancing.
   2. Train Test and Balance Subcontractor to use control system interface tools.
   3. Provide a qualified technician to assist with testing and balancing the first 20 terminal units.
   4. Test and Balance Subcontractor shall return tools undamaged and in working condition at completion of testing and balancing.

C. Life Safety.
   1. Duct smoke detectors required for air handler shutdown are provided under Division 28. Interlock smoke detectors to air handlers for shutdown.
   2. Fire and smoke dampers and actuators required for fire-rated walls are provided under Division 23. Fire and smoke damper control is provided under Division 28.

D. Coordination with Other Controls. Integrate with and coordinate controls and control devices furnished or installed by others as follows.
   1. Communication media and equipment shall be provided as specified.
   2. Each supplier of a controls product shall configure, program, start up, and test that product to meet the sequences of operation as described.
   3. Coordinate and resolve incompatibility issues that arise between control products provided under this section and those provided under other sections or divisions of this specification.
   4. Controls Subcontractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.

GENERAL WORKMANSHIP

A. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

B. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

C. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

D. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

E. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

FIELD QUALITY CONTROL

A. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances.

B. Continually monitor field installation for code compliance and workmanship quality.

C. Subcontractor shall arrange for work inspection by local or state authorities having jurisdiction over the work.

WIRING

A. Control and interlock wiring and installation shall comply with national and local electrical codes, Division 26, and manufacturer's recommendations.

B. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC and Division 26.

C. Low-voltage wiring shall meet NEC Class 2 requirements. Subfuse low-voltage power circuits as required to meet Class 2 current limit.

D. NEC Class 2 (current-limited) wires not in raceway but in concealed and accessible locations such as return air plenums shall be UL listed for the intended application.

E. Install wiring in raceway where subject to mechanical damage and at levels below 3 m (10ft) in mechanical, electrical, or service rooms.

F. Install Class 1 and Class 2 wiring in separate raceways. Boxes and panels containing high-voltage wiring and equipment shall not be used for low-voltage wiring except for the purpose of interfacing the two through relays and transformers.

G. Do not install wiring in raceway containing tubing.

H. Secure raceways with raceway clamps fastened to structure and spaced according to code requirements. Raceways and pull boxes shall not be hung on or attached to ductwork, electrical raceways, piping, or ceiling suspension systems.

I. Size raceway and select wire size and type in accordance with manufacturer's recommendations and NEC requirements.

J. Include one pull string in each raceway 2.5 cm (1 in.) or larger.

K. Use color-coded conductors throughout.

L. Locate control and status relays in designated enclosures only. Do not install control and status relays in packaged equipment control panel enclosures containing Class 1 starters.

M. Conceal raceways except within mechanical, electrical, or service rooms. Maintain minimum clearance of 15 cm (6 in.) between raceway and high-temperature equipment such as steam pipes or flues.

N. Adhere to requirements in Division 26 where raceway crosses building expansion joints.

O. Install insulated bushings on raceway ends and enclosure openings. Seal top ends of vertical raceways.

P. Terminate control and interlock wiring related to the work of this section. Maintain at the job site updated (as-built) wiring diagrams that identify terminations.

Q. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Do not use flexible metal raceway less than ½ in. electrical trade size. Use liquid-tight flexible metal raceways in areas exposed to moisture including chiller and boiler rooms.

R. Install raceway rigidly, support adequately, ream at both ends, and leave clean and free of obstructions. Join raceway sections with couplings and according to code. Make terminations in boxes with fittings. Make terminations not in boxes with bushings.

COMMUNICATION WIRING

A. Communication wiring shall be low-voltage Class 2 wiring and shall comply with Article 3.7 (Wiring).

B. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

C. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

D. Verify entire network’s integrity following cable installation using appropriate tests for each cable.

E. Install lightning arrestor according to manufacturer’s recommendations between cable and ground where a cable enters or exits a building.

F. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

G. Label communication wiring to indicate origination and destination.

H. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

FIBER OPTIC CABLE

A. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

B. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

COMMUNICATION SPEED PERFORMANCE

A. The communication speed between the control units and operator workstation shall be sufficient to ensure fast system response time under moderately heavy network traffic conditions. The control system architecture and hardware and software selection and installation shall result in no data transfer slow-downs between secondary controllers supervisory controllers and the operator workstation. All sequences of control described in the specifications shall be executed by the control system without delayed control or a skipped sample or control sequence. This requirement applies during normal operation during some alarms, simultaneous trend logs being taken of 25% of the total number of system points at a 2 minute sampling rate and other events to simulate moderately heavy network traffic.
1. The Subcontractor shall submit calculations and explanations of the system architecture indicating how these requirements will be met.
2. The subcontractor shall submit a plan and explanation of how moderately heavy traffic shall be simulated for testing each of the following requirements and how these requirements will be demonstrated with representative events so as to not circumvent the intent of the tests. Requirements do not apply when a remote connection must be established via dial-up modems or via the Engineer's LAN system.
3. Test the system at the conditions listed above and with a witnessing Engineer represent, with the following acceptance criteria for maximum annunciation or update times at the operator work station:
   a. Level 1 alarm (critical): 20 seconds.
   b. Level 2 alarm: 20 seconds.
   c. Level 3-5 alarm: 20 seconds.
   d. Updating of values on a newly selected graphic: 30 seconds.
   e. Change of an input sensor value and it shown on the work station: 20 seconds.
   f. Changing of a setpoint via operator interface and the time to see the change in the controller: 20 seconds.
   g. Operator command to start/stop and time to see the command received in controller: 20 seconds.
   h. As necessary, additional supervisory interface or other peer-to-peer network controllers shall be added or control architecture modified to meet these requirements.

B. Values for all control and monitored points and critical software or calculated points shall be shown on the graphics screens at their physical location.

BUILDING CONTROLLER INSTALLATION

A. Subcontractor shall install Building Controller (BC) and any required input/output interface devices, all in appropriate enclosures as indicated on the subcontract drawings. Subcontractor shall provide and install all appropriate appurtenances, devices and terminate all input/output wiring. Subcontractor shall test and prove connection and function for all components from the BC to the sensed or controlled element prior to initially placing the BC in control of any equipment or devices.

B. All BCs shall be securely attached to a wall in approximately the location indicated or specified, or in locations proposed by the Subcontractor and approved by the Engineer. Location of BCs shall be subject to Engineer’s approval, shall provide easy access for servicing and use, and shall afford a minimum of exposure to hazards.

C. Mount all enclosures so that the top does not exceed six feet, six inches (6’-6"); and the center of any keypad/LCD combination does not exceed five foot, six inches (5’-6") from the floor.

D. Power supply to the BC shall be 120 VAC, 60 Hz, and shall be permanently installed from a dedicated circuit breaker
    1. The 120VAC supply to the FMCS panel shall be housed in a separate, dedicated and suitably grounded metal enclosure (indoor and/or outdoor use)with a 120VAC grounded receptacle external to the 120VAC circuit. The panel shall also house a transformer to reduce the voltage to less than 50VAC or DC. The 50VAC and/or DC conductors shall be placed in a dedicated conduit to provide power to a separate, dedicated and suitably grounded metal enclosure (indoor and/or outdoor use) for BC. A 120VAC master disconnect switch capable of being locked and tagged (LOTO compliant) shall be installed to remove power from the panel. Any additional external 120VAC control or branch circuit power source coming into the BC panel shall comply with the above.Plug and receptacle power connection for the BC or any component of the BC (e.g. power supply) is specifically prohibited. Connection to a circuit breaker with other existing loads is specifically prohibited except with the express written permission of the Engineer.

E. Power supply circuit breakers shall be labeled on the breaker panel schedule as "FMCS" and shall list the BC number(s) and location(s) served.

F. Subcontractor shall field verify all information provided for equipment and controls, including but not limited to; spring ranges for pneumatic actuators, voltage levels for electrical controls, interlocks of equipment, and equipment and device locations.

G. Permanently and effectively ground all conduit systems, supports, cabinets, panelboards, light fixtures, motor frames and non-current carrying parts of other electrical equipment in accordance with the NEC. Ground transformer neutrals in accordance with requirements of the NEC.

APPLICATION SPECIFIC CONTROLLERS AND INTEGRATORS

A. Mount all ASC and Integrator enclosures so that the top of any panel does not exceed six feet, six inches (6’-6"). All components shall be permanently mounted in a fashion which permits troubleshooting, calibration, access to switches or jumpers, replacement of fuses, and resetting circuit breakers without removing components from the enclosure.

B. The ASC and Integrator enclosures shall be installed in the locations shown on the drawings.

C. Plug and receptacle power connection for the ASCs, Integrators or any component of the FMCS (e.g. power supply) is specifically prohibited. Connection to a circuit breaker with other existing loads is specifically prohibited except with the express written permission of the Engineer.

D. Permanently and effectively ground all conduit systems, supports, and cabinets in accordance with the CEC. Ground transformer neutrals in accordance with requirements of the CEC.

E. All components shall be mounted in a fashion that permits a direct viewing of status lights and display panels from the front of the enclosure.

F. Wiring shall conform to CEC Articles 725, 760, and 800 and to UL 508. Digital and analog input/output wiring methods in conformance with CEC Article 725 Class 2 are allowable, except as otherwise specified or indicated on the subcontract drawings.

INSTALLATION OF SENSORS

A. Install sensors according to manufacturer’s recommendations.

B. Mount sensors rigidly and adequately for operating environment.

C. Install room temperature sensors on concealed junction boxes properly supported by wall framing.

D. Calibration
1. All sensors shall be calibrated. Coordinate calibration requirements with Section 15990 – Testing, Adjusting, and Balancing to provide measuring equipment and labor to make the measurements needed to perform required calibrations on hydronic flow and pressure meters, air flow stations, air pressure sensors, etc.
2. Calibration after installation shall be to within 1.5% of specified span.
3. Calibrate every current monitoring (CM) relay. Measure and document the load current. Increase the number of turns through the toroid so that the minimum ampere-turns are 2.5. For fixed loads such as circulation pumps, set trip at 90% of the ampere-turns. For relatively fixed loads such as non-variable-air-volume fans, set trip at 80% of the ampere-turns or at 50% of the nameplate-RLA-times-number-of-turns, whichever is greater.

E. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

F. Use averaging sensors in mixing plenums and hot and cold decks. Install averaging sensors in a serpentine manner vertically across duct. Support each bend with a capillary clip.

G. Install mixing plenum low-limit sensors in a serpentine manner horizontally across duct. Support each bend with a capillary clip. Provide 3 m (1 ft) of sensing element for each 1 m2 (1 ft2) of coil area.

H. Install pipe-mounted temperature sensors in wells. Install liquid temperature sensors with heat-conducting fluid in thermal wells.

I. Install outdoor air temperature sensors on north wall at designated location with sun shield.

J. Differential Air Static Pressure.

1. Supply Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer’s recommendations.
2. Return Duct Static Pressure. Pipe high-pressure tap to duct using a pitot tube. Make pressure tap connections according to manufacturer’s recommendations.
3. Building Static Pressure. Pipe pressure sensor’s low-pressure port to the static pressure port located on the outside of the building through a high-volume accumulator. Pipe high-pressure port to a location behind a thermostat cover.
4. Piping to pressure transducer pressure ports shall contain a capped test port adjacent to transducer.
5. Pressure transducers, except those controlling VAV boxes, shall be located in control panels, not on monitored equipment or on ductwork. Mount transducers in a vibration-free location accessible for service without use of ladders or special equipment.
6. Mount gauge tees adjacent to air and water differential pressure taps. Install shut-off valves before tee for water gauges.

K. Smoke detectors, freezestats, high-pressure cut-offs, and other safety switches shall be hard-wired to de-energize equipment as described in the sequence of operation. Switches shall require manual reset. Provide contacts that allow DDC software to monitor safety switch status.

FLOW SWITCH INSTALLATION

A. Use correct paddle for pipe diameter.

B. Adjust flow switch according to manufacturer’s instructions.

ACTUATORS

A. General. Mount actuators and adapters according to manufacturer’s recommendations.

B. Electric and Electronic Damper Actuators. Mount actuators directly on damper shaft or jackshaft unless shown as a linkage installation. Link actuators according to manufacturer’s recommendations.
1. For low-leakage dampers with seals, mount actuator with a minimum 5° travel available for damper seal tightening.
2. To compress seals when spring-return actuators are used on normally closed dampers, power actuator to approximately 5° open position, manually close the damper, then tighten linkage.
3. Check operation of damper-actuator combination to confirm that actuator modulates damper smoothly throughout stroke to both open and closed positions.
4. Provide necessary mounting hardware and linkages for actuator installation.

C. Valve Actuators. Connect actuators to valves with adapters approved by actuator manufacturer.

D. Mount actuator in an easily accessible location with clearance in front for visual reading of damper position. Mark damper shaft for closed and open position. Manufacturer and model number shall be clearly visible on installed valve and actuator.

E. Where 24 VAC or 24 VDC direct-coupled actuators are utilized (such as Belimo SF-24 SR), subcontractor shall provide required Class-2 rated control transformer at FPU to power new actuators. Subcontractor shall provide drawing revisions. Control signal wiring may be run in same conduit with 24 VAC or 24 VDC actuator power wire.

F. A rain cover shall be provided and installed on actuators mounted outside of a building.

G. Subcontractor shall establish and document actual endpoints of each actuator's range in the field at the actuator, E/P (if any), and controller output voltage or current. The control range shall be established to match the actuator range. For outputs controlling only one actuator (or multiple actuators of the same type and direction of operation), engineering units shall be in "% OPEN" for dampers and valves (open to coil for three-way valves). For outputs controlling more than one actuator in opposite directions (e.g. normally open heating and normally closed cooling), engineering units shall be in "% CMD". The corresponding analog data object used for monitoring shall include in the description the range and normal position of the actuators controlled.

MOTORIZED BUTTERFLY VALVES

A. Install and wire where indicated per the manufacturer's recommendations

B. Provide 120V power to the actuator as required. Any 120VAC control or branch circuit power source coming in to the actuator shall be fully isolated from service or installation personnel contact.

AIRFLOW MEASURE STATION

A. Install and wire airflow measuring station where indicated per the manufacturer's instruction.

B. Seal all bolts and screw installation in the exhaust fan inlet with the same epoxy coating or sika flex 1A sealant.

WARNING LABELS

A. Affix permanent warning labels to equipment that can be automatically started by the control system.
1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N This equipment is operating under automatic control and may start or stop at any time without warning. Switch disconnect to "Off" position before servicing.

B. Affix permanent warning labels to motor starters and control panels that are connected to multiple power sources utilizing separate disconnects.
1. Labels shall use white lettering (12-point type or larger) on a red background.
2. Warning labels shall read as follows.

C A U T I O N This equipment is fed from more than one power source with separate disconnects. Disconnect all power sources before servicing.

IDENTIFICATION OF HARDWARE AND WIRING

A. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

B. Permanently label or code each point of field terminal strips to show instrument or item served.

C. Label control panels with minimum 2.5 cm (1 in.) letters on laminated plastic nameplates.

D. Each input sensor, output transducer, relay, or other input/output device shall be indelibly and conspicuously identified with the alphanumeric hardware object identification name as specified in the Input/Output Objects List.
   1. Zone sensors shall be labeled with the Field address and the terminal box number on the inside of the cover.

E. All I/O field devices that are not mounted within field device panel enclosures shall be identified with nameplates installed so that they are visible from ground level.

F. All I/O field devices that are mounted within field device panel enclosures shall be identified with an adhesive backed metalized polyester film label, Brady #B969. Label information shall be printed on the label with a laser printer.

G. Calibration settings shall be marked with paint or indelible ink.

H. Label room sensors related to terminal boxes or valves with nameplates.

I. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

J. Label identifiers shall match record documents.

CURRENT AND POTENTIAL TRANSFORMER INSTALLATION

A. Schedule a shutdown of the power systems to be monitored in accordance with Division 1- "Special Provisions".

B. All other components required for the power metering must be installed prior to the shutdown. This includes shorting blocks, test switches, kW/kWh transducers, conduit, wire, and as many terminations as possible.

C. Perform work in a manner which limits the shutdown period to the absolute minimum.

D. Installation must be inspected by the ENGINEER Maintenance & Operation Electrical staff prior to re-energizing building power.

OPERATOR INTERFACE

A. Locate the System Operator work station in Building 76 Room 123 or 129A as directed by the Engineer. The Engineer will provide power and Ethernet connection for communications with other Building ALC network controller on Campus.

B. Turn in the portable operator terminal to the Engineer after the unit has been programmed and tested.

PROGRAMMING

A. Point Naming. Names of all software and hardware points shall be consistent with point naming conventions on all of the existing LBNL ECMS and/or FMCS systems. Consult with LBNL for guidance in this area. If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix B may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "ZAT1" for Zone 1, "ZAT2" for Zone 2.

B. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.
   1. Application Programming. Provide application programming that adheres to sequences of operation specified. Program documentation or comment statements shall reflect language used in sequences of operation.
   2. System Programming. Provide system programming necessary for system operation.

C. Operator Interface.
   1. Graphics
      a. Develop customized graphics showing the project building(s) and their floor plans, mechanical equipment, flow and control diagrams, and other relevant features the graphic screens. Associated input, output, and virtual objects (e.g., temperature & pressure set points) listed in the Sequence of Operation, and shown on the Input/Output Objects List shall be included in the graphic screens and bound to the database. The real-time value of all objects shall be updated on the display of each graphic automatically. AutoCAD drawings of the building(s) floor plans, available flow and control diagrams, equipment schematics, existing graphics of each type, and other details will be provided to the Subcontractor.
      b. All graphics shall have links to the Print function and to display the Engineer Standard Legend in the upper left-hand corner of the graphic. All graphics, except pop-ups, shall have the date and time displayed in the upper left-hand corner of the graphic. Each graphic shall be titled and contain the Engineer Logo. Samples will be provided to the subcontractor.
      c. Weather - All graphics, except pop-ups, shall have the outdoor temperature and humidity in the upper left hand corner of the graphic.
      d. Alarms - System and component summary alarms shall be located near the top of each relevant graphic screen. Provide links to the associated system/component as part of these tags to assist trouble shooting. Other alarms shall be placed near the associated system/device as depicted in the graphic. The text and color of information tags that describe each object and alarm value shall be consistent with the Engineer graphics color legend. These tags shall be coordinated with, and approved by, the Engineer project manager.
      e. The following graphics shall be provided as a minimum:
         1) A building graphic, typically a photograph of the building, with links to each floor plan and other links as defined below.
         2) Floor plans of each floor, with temperature sensors, pressure sensors, temperature control zones, and supply air zones identified. Rooms shall be grouped on a graphic only to the extent that detailed and complete sensing information can be comfortably viewed by an operator and the

bound points updated in less than 30 seconds. Each zone shall have a temperature symbol that changes color over the range from low (blue) through normal (green) to high (red) and indicate an alarm (flashing red). The zone temperature symbol shall also be a link to a zone control pop-up graphic. The individual floor plan graphics shall provide links to related mechanical systems. The mechanical room plan graphics shall show the relative location of, and provide links to, either the equipment pop-up or flow & control graphic for all mechanical equipment monitored or controlled by the FMCS.

3) Pop-up graphics shall be provided for each zone control system showing a flow diagram and all related monitoring & control points and system parameters. Pop-up graphics shall be provided for each piece of equipment that is not shown on a flow and control graphic.

4) Flow and control diagrams for each mechanical system including air-handling units, packaged equipment, chilled water systems, and heating hot water systems. The flow and control graphics shall have parameters grouped in the lower portion of the graphics. Standard equipment graphics shall be used as provided by Engineer. Pumps, fans, dampers and other elements shall dynamically indicate their state (i.e. pumps and fans shall rotate when on and damper positions shall dynamically adjust and be shown in their current position, etc.). All system flow and control graphics shall be displayed in a general left to right flow or loop arrangement. Return and exhaust air flow shall be shown on top and return water shall be shown on the bottom of the graphic.

5) Individual equipment/component screens showing all sensing and control information available for each device shall be provided.

f. Penetration – The graphic interface shall consistently apply a convention whereby a left-click shall always penetrate to more detailed information. A right-click shall always produce a menu of options that are specific to the item selected.

g. Navigation - The graphics shall be organized to provide a "branching structure" that allows an operator to move from a "macro view" to a "micro view" and return. For example, the branching structure shall start with the Engineer site map, lead to a building, and move to its floors, zones, and conditioning systems. These links (a.k.a. "jumps") to all other associated graphics, or allow a return to a previous macro view, shall be provided and arranged horizontally along the bottom of each graphic screen. From left to right, the graphic links shall be as follows: site/building map, all building/trailer floor plans, and major mechanical systems. Pop-up right click menus shall be provided as needed on the lower button bar to allow for uncluttered navigation.

h. Clutter Minimization - Each graphic shall have separate check boxes in the lower right corner that show/hide setpoints, alarms/safeties, and Devices/Equipment.

i. Templates – To the maximum extent possible, the subcontractor shall use existing Engineer graphics as templates to provide a consistent look throughout the interface. New graphic templates developed for this project shall conform to Engineer’s standard convention.

j. Color Scheme – The graphics shall use dynamic color changes to communicate equipment type, or object status consistent with the Engineer graphics color legend.

k. Symbols and Animations: Fans, pumps, dampers, coils, and generation equipment shall be dynamics symbols indicating rotation, state, or position, movement, flow, etc.
l. Style – The graphics shall be 2-dimensional, equivalent to level 2 as defined in the North American Style Guide, Appendix A: Graphics Style Guide, FAN-55.010.
m. Macros – When macros are used to add functionality to the graphics, detailed documentation shall be provided.
n. Configure Mode – Access to “Configure Mode” for editing of the graphics shall be password protected to prevent unauthorized changes to the graphics. This password shall be supplied to the appropriate Engineer personnel.
o. All points and graphics shall be checked for the proper binding and graphic programming, settings to ensure that the correct system, location, point values and dynamics are shown in the proper location and rotate in the proper directions.
p. After all graphics have been accepted they shall be provided on a CD ROM in an agreed upon file structure. If the graphics have active-x controls or other files that must be placed outside the graphics folder structure a set-up program shall be provided on the disk to place the files in the correct locations.

2. Program both workstation and portable operator’s terminal to include all software necessary for access, operation, monitoring, diagnostic, and trouble shooting of the FMCS.
3. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation).

CONTROL SYSTEM CHECKOUT AND TESTING

A. Startup Testing. Complete startup testing to verify operational control system before notifying Engineer of system demonstration. Provide Engineer with schedule for startup testing. Engineer may have representative present during any or all startup testing.
1. Calibrate and prepare for service each instrument, control, and accessory equipment furnished under this section.
2. Verify that control wiring is properly connected and free of shorts and ground faults. Verify that terminations are tight.
3. Enable control systems and verify each input device’s calibration. Calibrate and document each device according to manufacturer’s recommendations.
4. Verify that binary output devices such as relays, solenoid valves, two-position actuators and control valves, and magnetic starters, operate properly and that normal positions are correct.
5. Verify that analog output devices such as I/Ps and actuators are functional, that start and span are correct, and that direction and normal positions are correct. Check control valves and automatic dampers to ensure proper action and closure. Make necessary adjustments to valve stem and damper blade travel.
6. Prepare a log documenting startup testing of each input and output device, with technician’s initials certifying each device has been tested and calibrated.
7. Verify that system operates according to sequences of operation. Simulate and observe each operational mode by overriding and varying inputs and schedules. Tune PID loops and each control routine that requires tuning.
8. Alarms and Interlocks.
a. Check each alarm with an appropriate signal at a value that will trip the alarm.

b. Trip interlocks using field contacts to check logic and to ensure that actuators fail in the proper direction.
c. Test interlock actions by simulating alarm conditions to check initiating value of variable and interlock action.

CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

A. General
1. Provide all labor and equipment necessary to perform a comprehensive acceptance test of object-by-object proof of function for each input and output object, prior to the acceptance testing witnessed by the Engineer and defined below. Complete one of each applicable testing form submitted and approved in the Pre-Commissioning Submittals. A copy of each form shall be submitted to the LBNL Project Manager within 24 hours of completion.
2. Under the supervision of the Engineer, provide all labor and equipment necessary to perform a comprehensive acceptance test of object-by-object proof of function for each input and output object. Contact the Engineer to schedule the testing at least two weeks prior to the time at which the system will be prepared to undergo the tests.
a. Refer to Section 23 08 00 Commissioning of HVAC.
3. Provide all labor and equipment necessary to perform a comprehensive acceptance test of the sequence of operation proof of function for each system, prior to the acceptance testing witnessed by the Engineer and defined below. Use the Sequence of Operation to measure the performance of the FMCS against the subcontract documents. A copy of Sequence of Operation with the Subcontractors notes recording proof of function shall be submitted to the Project Manager within 24 hours of completion.
4. Under the supervision of the Engineer, provide all labor and equipment necessary to perform a comprehensive acceptance test of the sequence of operation proof of function for each system. Contact the Engineer to schedule the testing at least two weeks prior to the time at which the system will be prepared to undergo the tests. Acceptance testing shall include, but not be limited to the following:
a. Calculated values.
b. PID loop control.
c. Events driven by schedule, interlocks, or other events or conditions.
d. FMCS control under power fail/restart conditions.
e. All functions defined in the Sequence of Operation.
5. The pushbutton override capability of the system shall be tested for each zone temperature setpoint.
6. The FMCS will not be accepted until all tests described in this section have been performed to the satisfaction of the Project Manager. Any tests that cannot be performed due to circumstances beyond the control of the Subcontractor shall be exempt from the system acceptance requirements if stated as such in writing by the Project Manager. Such tests shall be performed as part of the FMCS warranty.

B. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified in Article 3.17 (Control System Checkout and Testing). Provide Engineer with log documenting completion of startup tests.
1. Engineer will be present to observe and review system demonstration. Notify Engineer at least 10 days before system demonstration begins.
2. Demonstration shall follow process submitted and approved. Complete approved checklists and forms for each system as part of system demonstration.

3. Demonstrate actual field operation of each sequence of operation as specified. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Engineer. Provide and operate test equipment required to prove proper system operation.
4. Demonstrate compliance with System Performance.
5. Demonstrate compliance with sequences of operation through each operational mode.
6. Demonstrate complete operation of operator interface.
7. Demonstrate each of the following.
   a. DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Engineer will require further tuning of each loop that displays unreasonably under- or over-damped control.
   b. Demand limiting. Supply trend data output showing demand-limiting algorithm action. Trend data shall document action sampled each minute over at least a 30-minute period and shall show building kW, demand-limiting setpoint, and status of setpoints and other affected equipment parameters.
   c. Building fire alarm system interface.
   d. Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for use in other software programs.
8. Tests that fail to demonstrate proper system operation shall be repeated after Subcontractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

C. Acceptance.
1. After tests described in this specification are performed to the satisfaction of both Engineer, the Engineer and Commissioning Agent, Engineer will accept control system as meeting completion requirements. Engineer may exempt tests from completion requirements that cannot be performed due to circumstances beyond Subcontractor's control. Engineer will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.
2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved.

SYSTEM OPTIMIZATION

A. The Subcontractor shall provide 4 hours of system optimization to modify the application software to account for field conditions discovered during commissioning and testing.

CLEANING

A. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

B. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

C. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

TRAINING

A. Provide training in accordance with Division 1 requirements for a designated staff of Engineer's representatives. Training shall be provided via onsite classroom or field training..

B. Training shall enable students to accomplish the following objectives.
1. Proficiently operate system
2. Understand control system architecture and configuration
3. Understand DDC system components
4. Understand system operation, including DDC system control and optimizing routines (algorithms)
5. Operate workstation and peripherals
6. Log on and off system
7. Access graphics, point reports, and logs
8. Adjust and change system setpoints, time schedules, and holiday schedules
9. Recognize common HVAC system malfunctions by observing system graphics, trend graphs, and other system tools
10. Understand system drawings and Operation and Maintenance manual
11. Understand job layout and location of control components
12. Access data from DDC controllers
13. Operate portable operator's terminals
14. Create and change system graphics
15. Create, delete, and modify alarms, including configuring alarm reactions
16. Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
17. Configure and run reports
18. Add, remove, and modify system's physical points
19. Create, modify, and delete application programming
20. Add operator interface stations
21. Add a new controller to system
22. Download firmware and advanced applications programming to a controller
23. Configure and calibrate I/O points
24. Maintain software and prepare backups
25. Interface with job-specific, third-party operator software
26. Add new users and understand password security procedures

C. Divide presentation of objectives into three sessions (1-13, 14-23, and 24-26). Participants will attend one or more of sessions, depending on knowledge level required.

D. Provide one copy of course outline and materials per student.

E. Instructors shall be certified by the manufacturer as a trainer and experienced in presenting this material.

F. Perform classroom training using a network of working controllers representative of installed hardware.

SEQUENCE OF OPERATION

A. As shown on the drawings and instructed by the Engineer.

APPENDIX A: Glossary of Terms

Terms used within the Specification Text:

- Advanced Application Controller (AAC):

  A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet.

- Application Specific Controller (ASC):

  A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions.

- BACnet/IP:

  An approved BACnet network type which uses an Ethernet carrier and IP addressing.

- BACnet MS/TP:

  An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps.

- BACnet over ARCNET:

  An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps.

- Building Controller (BC):

  A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller.

- Direct Digital Control (DDC):

  A control system in which a digital computer or microprocessor is directly connected to the valves, dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting setpoints on an analog pneumatic or electronic controller.

- PICS - Protocol Implementation Conformance Statement:

  A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device.

- Smart Actuator (SA):

  An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.)

- Smart Sensor (SS):

  A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.)

- Web services:

  Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

Terms used within the Sequences of Operation:

- adj.

  Adjustable by the end user, through the supplied user interface.

- AI, AO, etc. (Column Headings on Points List)

  AI = Analog Input. A physical input to the control module.
  AO = Analog Output. A physical output from the control module.
  AV = Analog Value. An intermediate (software) point that may be editable or read-only. Editable AVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only AVs are typically used to display the status of a control operation.
  BI = Binary Input. A physical input to the control module.
  BO = Binary Output. A physical output from the control module.
  BV = Binary Value. An intermediate (software) point that may be editable or read-only. Editable BVs are typically used to allow the user to set a fixed control parameter, such as a setpoint. Read Only BVs are typically used to display the status of a control operation.
  Sched = Schedule. The control algorithm for this equipment shall include a user editable schedule.
  Trend. The control system shall be configured to collect and display a trend log of this object. The trending interval shall be no less than one sample every 5 minutes. (Change of Value trending, where a sample is taken every time the value changes by more than a user-defined minimum, is an acceptable alternative.)
  Alarm. The control system shall be configured to generate an alarm when this object exceeds user definable limits, as described in the Sequence of Controls.

Note: If the specifications require use of the BACnet protocol, all of the above shall be provided as BACnet objects.

- KW Demand Limiting: *

  An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold.

  When power consumption exceeds defined levels, the system automatically adjust setpoints, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner.

- Occupant Override Switch, or Timed Local Override:

  A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time.

  When the override time expires, the zone returns to its unoccupied state.

- Occupant Setpoint Adjustment:

  A control option that allows building occupants to adjust - within limits set by the HVAC control system - the heating and cooling setpoints of selected zones. Typically the user interface for this function is built into the zone sensor.

- Optimal Start-Up: *

  A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied.

  In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied setpoint.

  The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity.

  A distributed system must use Run on Request with Optimal Start. (See below.)

- Requested, or Run on Request: *

  A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule.

  The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment.

For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller.

The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.

- Trim and Respond, or Setpoint Optimization: *

  A control strategy that optimizes the setpoint of a source piece of equipment that supplies one or more receiving units - such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service.

  The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its setpoint.

  For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air setpoint. When a zone requests cooling, the AHU responds by dropping its setpoint. The more zones that request cooling, the more it drops the setpoint. The AHU repeats this process throughout the day to keep zones cool, but with a supply air setpoint that is no cooler than necessary.

Contracting Terms:

- Furnished or Provided:

  The act of supplying a device or piece of equipment as required meeting the scope of work specified and making that device or equipment operational. All costs required to furnish the specified device or equipment and make it operational are borne by the division specified to be responsible for providing the device or equipment.

- Install or Installed:

  The physical act of mounting, piping or wiring a device or piece of equipment in accordance with the manufacturer's instructions and the scope of work as specified. All costs required to complete the installation are borne by the division specified to include labor and any ancillary materials.

- Interface:

  The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system.

- Integrate:

  The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system.

APPENDIX B: Abbreviations

The following point naming conventions may be used in graphics, schematics, point names, and other UI applications where space is at a premium.

NAME	**DESCRIPTION**	**UNITS**
ACK-ALM	ALARM ACKNOWLEDGEMENT INPUT POINT	NORMAL/ALARM
ALARM	GENERAL ALARM INPUT (REAL OR VIRTUAL)	NORMAL/ALARM
ALM-HORN	ALARM HORN OUTPUT CONTROL	NORMAL/ALARM
ALM-LITE	ALARM LIGHT OUTPUT CONTROL	NORMAL/ALARM
BYP	OCCUPANT BYPASS DIGITAL INPUT	UNOCC/OCC
CD-SAT	COLD DECK SUPPLY AIR TEMPERATURE	DEGF
CHW-FLOW	CHILLED WATER FLOW DATA	GPM
CHW-ISO	CHILLED WATER ISOLATION VALVE	% OPEN
CHWR	CHILLED WATER RETURN TEMPERATURE	DEGF
CHW-HI	CHILLED WATER HIGH RESET VALUE	DEGF
CHW-LO	CHILLED WATER LOW RESET VALUE	DEGF
CHWS	CHILLED WATER SUPPLY TEMPERATURE	DEGF
CHWV	CHILLED WATER CONTROL VALVE	% OPEN
COMP-X	COMPRESSOR X	
CZSP	COOLING ZONE TEMPERATURE SETPOINT	DEGF
DAMPER	DAMPER OUTPUT CONTROL POINT	% OPEN
DHWV	DOMESTIC HOT WATER CONTROL VALVE	% OPEN
DMP-CLS	DAMPER OUTPUT CONTROL POINT-CLOSE(INCREMENTAL)	% CLOSED
DMP-OPN	DAMPER OUTPUT CONTROL POINT-OPEN (INCREMENTAL)	% OPEN
DSP-SP	DUCT STATIC PRESSURE SETPOINT	IN WC
DUCT-SP	DUCT STATIC PRESSURE	IN WC
ECON-DMP	ECONOMIZER CONTROL DAMPER	% OPEN
FANPWRBX	FAN POWERED BOX	
FAULT	VFD FAULT INPUT	NORMAL/ALARM
FHX-VEL	FUME HOOD VELOCITY INPUT (FH1-VEL, FH2-VEL, ETC.)	FPM
FILT-ALM	BINARY FILTER DIFFERENTIAL PRESSURE ALARM	NORMAL/ALARM
FILT-DP	ANALOG FILTER DIFFERENTIAL PRESSURE	IN WC
H2O-LEAK	WATER LEAK DETECTOR	NORMAL/ALARM
HD-SAT	HOT DECK SUPPLY AIR TEMPERATURE	DEGF
HEPA-DP	HEPA FILTER DIFFERENTIAL PRESSURE	IN WC
HHWR	HEATING HOT WATER RETURN TEMPERATURE	DEGF
HHWS	HEATING HOT WATER SUPPLY TEMPERATURE	DEGF
HHWS-SP	HEATING HOT WATER SUPPLY TEMP. SETPOINT	DEGF
HHWV	HEATING HOT WATER CONTROL VALVE	% OPEN
HZSP	HEATING ZONE TEMPERATURE SETPOINT	DEGF
IHWV	INDUSTRIAL HOT WATER CONTROL VALVE	% OPEN
INLTVANE	INLET VANE CONTROL POINT	% OPEN
LCWV	LCW FLOW CONTROL VALVE	% OPEN
OAT	OUTSIDE AIR TEMPERATURE	DEGF
OCC	OCCUPIED	UNOCC/OCC
PSP-SP	PUMP STATIC PRESSURE SETPOINT	IN H2O
RDP-SP	ROOM TO CORRIDOR DIFFERENTIAL PRESSURE SETPOINT	IN WC
ROOM-DP	ROOM TO CORRIDOR DIFFERENTIAL PRESSURE	IN WC
SAT	SUPPLY AIR TEMPERATURE	DEGF

SPD-CTL	VFD SPEED CONTROL OUTPUT	% CMD
SPEED	VFD SPEED FEEDBACK	HZ
SS	START/STOP CONTROL	ON/OFF
STAGE-X	(COMPRESSOR) STAGE X	
STATUS	EQUIPMENT STATUS INPUT	ON/OFF
TRW-FLOW	TREATED WATER FLOW VALUE	GPM
TRWR	TREATED WATER RETURN TEMPERATURE	DEGF
TRWS	TREATED WATER SUPPLY TEMPERATURE	DEGF
TRWV-CLS	TREATED WATER VALVE ’CLOSE’ COMMAND (INCREMENTAL)	% CLOSED
TRWV-OPN	TREATED WATER VALVE ’OPEN’ COMMAND (INCREMENTAL)	% OPEN
VIB-MON	VIBRATION SENSOR MONITOR INPUT	NORMAL/ALARM
ZAT	ZONE AIR TEMPERATURE	DEGF
ZSP	ZONE TEMPERATURE SETPOINT	DEGF

END OF SECTION 255000