ALEXANDRA PARK

MECHANICAL SPECIFICATIONS

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DIVISION 15 - MECHANICAL

1. **INSTRUCTIONS TO BIDDERS**

.1 Contractors shall visit site prior to bidding to familiarize themselves with the existing conditions.

2. **LIAISON**

.1 The Contractor shall attend regular site meetings. He shall coordinate through the Construction Manager, the work of this package accounting for the other contractors on site, in a safe and cooperative working environment. Due to the design characteristics of this project the Contractor shall work closely with other trades through the Construction Manager so that critical areas are installed on time and after other construction criteria have been met.

3. **COST BREAKDOWN**

.1 The Contractor shall submit a cost breakdown, as directed by the Owner such to be used as a basis for payment evaluations. If the Consultant determines the breakdown submitted is unbalanced, it will be adjusted and his decision will be final. If further breakdown is required for valuation of work for progress payments, submit these within fourteen days of request.

4. **CONTRACTOR'S USE OF SITE**

.1 Contractors and their sub-contractors shall observe the rights of others in use of the site, and conform to directions of the Construction Manager.

.2 Do not unreasonably encumber site with materials or equipment.

.3 Move stored products or equipment which interfere with construction operations as directed by the Construction Manager.

4. Obtain and pay for use of additional storage or work areas needed for operations.

5. **CODES AND STANDARDS**

.1 Perform work in accordance with the current edition of the Ontario Building Code, ASHRAE 90.1, and any Local Municipal by law, all governing authorities having jurisdiction, and Fire commissioner provided that in any case of conflict or discrepancy, the more stringent requirements shall apply.

.2 Meet or exceed requirements of contract documents, specified standards, codes and reference documents.

.3 Where Standards are cited, e.g. CAN-A23.1-1977, CSA W186-1970, etc., it is intended that these Standards form the basis for the Specification Section. It is not intended that these Specifications take the place of Standards, but merely supplement them, unless otherwise specified.

.4 Whenever a Standard conflicts with the Contract Documents, the Contract Documents shall govern.

.5 All equipment and materials shall bear CGA, CSA label and conform to CGA, CSA, HEPC, ULC and ASME requirements.

6. **PROJECT MEETINGS**

.1 Attend project meetings as directed by the Construction Manager.

7. **SETTING OUT OF WORK**

.1 Care and control of project and site is the full responsibility of the Construction Manager. Ensure the project is carried forward in a proper manner and as expeditiously as possible.

.2 Include funds in Tender for co-ordination of work of all subtrades, and other contractors of the project, whether or not work is included in Contract, and arrange for execution and enforcement of all directives issued by the Consultant and the Construction Manager.

.3 Assume full responsibility for and execute complete layout of work to locations, lines and elevations indicated, unless overruled by the Construction Manager.

.4 Provide devices needed to lay out and construct work.

.5 Supply stakes and other survey markers required for laying out work.

.6 Prior to commencement of work, report in writing to the construction manager discrepancies that may affect work. Commencement of the work by the Contractor will constitute acceptance of the conditions found.

8. **SEPARATE CONTRACTS**

.1 The Owner reserves the right to award contracts for separate portions of work.

.2 Separate trade contractors will be instructed that the Construction Manager will have control of site; and co-operate in all phases of work to ensure proper and expeditious completion of project.

9. **LOCATION OF EQUIPMENT AND FIXTURES**

.1 Locations of equipment, fixtures and outlets indicated or specified are to be considered as approximate.

.2 Locate equipment, fixtures and distribution systems to provide minimum interference and maximum usable space and in accordance with manufacturer's recommendations for safety, access and maintenance.

.3 Inform Construction Manager of impeding installation and obtain his directives.

.4 Submit field drawings to indicate relative position of various services and equipment when required by Construction Manager.

10. **OVERLOADING**

.1 Load no part of the structure during construction with load greater than it is calculated to bear safely.

11. **CONCEALMENT**

.1 Conceal pipes, ducts and wiring in floor, wall and ceiling construction of finished areas except where indicated otherwise.

12. **CUTTING, FITTING AND PATCHING**

.1 Execute cutting (including excavation), fitting and patching required to make work fit properly.

.2 Where new work connects with existing and where existing work is altered, cut, patch and make good to match existing work.

.3 Obtain Construction Managers approval before cutting, boring or sleeving load-bearing members.

.4 Make cuts with clean, true, smooth edges. Make patches inconspicuous in final assembly.

.5 Fit work airtight to pipes, sleeves, ducts and conduit.

13. **EXISTING SERVICES**

.1 Where Work involves breaking into or connecting to existing services, carry out work at times directed by governing authorities, with minimum of disturbance to pedestrian and vehicular traffic.

.2 Before commencing Work, establish location and extent of service lines in area of work and notify the Construction Manager of findings.

.3 Submit schedule to and obtain approval from Construction Manager for any shut-down or closure of active service or facility. Adhere to approved schedule and provide notice to affected parties.

.4 Where unknown services are encountered, immediately advise Construction Manager and confirm findings in writing.

.5 Record locations of maintained, re-routed and abandoned service lines.

14. **ADDITIONAL DRAWINGS**

.1 Consultant may furnish additional drawings to assist proper execution of work. These drawings will be issued for clarification only. Such drawings shall have same meaning and intent as if they were included with plans referred to in Contract documents.

MECHANICAL GENERAL PROVISIONS

PART 1 - GENERAL

1.1 **GENERAL REQUIREMENTS**

.1 The specifications of Section 15010 apply to and govern all work of Division 15.

.2 Comply with the Instructions to Bidders, the General Conditions of the Contract Documents and all amendments and supplements thereto, and with General Requirements of Division 1.

.3 Included are all Federal and Provincial Taxes as well as applicable G.S.T.

1.2 **SCOPE OF WORK**

The listing hereinafter of any article, material, operation or method requires that the Contractor shall provide each item listed of the quality and subject to the qualifications noted, and the Contractor shall perform each operation prescribed according to the condition stated, providing therefore, all necessary labour, equipment and incidentals.

1.2.1 Work Included

.1 This Contractor shall include the supply of all labour, tools, equipment and materials for the installing, testing and putting into proper operation the complete system as herein specified

and as shown on drawings, or as is reasonably inferable from either or both.

.2 Equipment items that are supplied as packaged units under this Division shall include all internal wiring, relays, contactors, switches, transformers, motor starters, and controls etc. as required for the intended operation, and shall be complete with all necessary terminals suitable for connection to power source, and external controls at a single location.

1.2.2 Work under Separate Contract

.1 Incoming sanitary, storm, domestic cold water, and fire mains shall be carried under separate contract.

1.3 **INTENT**

.1 Any specific item or work omitted from one and which is mentioned or reasonably implied in the other shall be considered as properly and sufficiently specified and must be provided by this Contractor.

.2 Should any discrepancy appear between these specifications and the drawings which leave this Contractor in doubt as to the true meaning and intent of the drawings and specifications, a ruling shall be obtained from the Engineer before submitting his tender. If clarification is not sought prior to the closing of tender, the Engineer's decisions shall be final and conclusive and binding on the Contractor.

1.4 **REGULATION AND PERMITS**

.1 All work shall be carried out in accordance with the latest editions of all relevant authorities, codes, or regulations including but not limited to Ontario Building Code; Canadian Regulations for the Construction and Inspection of Pressure Vessels; Plumbing Code of the Province of Ontario, Gas Code, Fire Code, MOEE Regulation and H.E.P.C. of Ontario Code.

.2 All authorized code inspections required by above mentioned laws, rules and regulations, inclusive of any fees, obtaining of permits, and issuance of notices shall be arranged and paid for by Mechanical Contractor.

.3 Furnish all necessary certificates as evidence that work installed complied with aforementioned laws and regulations of all governing authorities, prior to acceptance and final certificate of payment is issued.

1.5 **EXAMINATION OF SITE**

This Contractor, before tendering, shall examine the site and all drawings and specifications of other trades and familiarize himself with local conditions, building construction and finish affecting the work under this section. No allowances shall be made for any extra expense incurred by him through his failure to do so.

1.6 **CONTRACT DRAWINGS**

.1 The Contract drawings are not intended to be shop or working drawings and all measurements shall be taken from the Architectural drawings or in the field. The Contractor shall make, without any extra expense or credit to the Owner, any necessary changes or additions to the work to accommodate the Architectural or Structural conditions. Where shop or working drawings are required, the Contractor shall provide them and submit them to the Engineer for approval.

.2 The Contract drawings show the minimum standard acceptable regardless of any lesser standards set by any codes or regulations having jurisdiction.

.3 The Architectural, Structural and Electrical, Landscape, Interior Design contract drawings are to be examined to ensure that work of this Division may be satisfactorily completed.

.4 Notify Engineer upon discovery of conditions which adversely affect work of this Division. No allowance will be made after letting of Contract for any expenses incurred through failure to do so.

1.7 **WORKING DRAWINGS**

.1 Before commencing any work the Contractor shall prepare working drawings. The Contractor may, if he wishes, make use of the Contract drawings and specifications as working drawings. However, he shall make any necessary calculation and changes to these drawing due to any substitution of equipment, materials, location and routing in order to make the systems fully operational as per original design.

.2 All changes and alterations required in either the drawings or in the work as it progresses by any authorized inspector of an authority having jurisdiction shall be carried out without any extra cost or credit to the Owner.

1.8 **RECORD DRAWINGS**

The Engineer will provide this trade with an extra set of white prints on which they shall show clearly in red ink, as the job progresses, all changes and deviations from location on plans. On completion of the work this trade shall provide to the Engineer two complete sets of drawings showing the exact location of all equipment, piping, etc., both inside and outside the building with dimensions to fixed reference points. These drawing shall be drawn to the same standard as the original contract drawings in AutoCAD format.

1.9 **MAINTENANCE DATA AND OPERATING INSTRUCTIONS**

.1 Submit three (3) copies of Operation and Maintenance Manual individually bound in hard backed three-ring binders.

.2 Front cover of each binder shall be suitably lettered as follows:

OPERATION AND MAINTENANCE MANUAL
FOR
ALEXANDRA PARK

.3 Provide plastic tab indices for all sections of the manual.

.4 Provide master index at the beginning of each binder indicating all items included.

.5 Provide lists of names, addresses and telephone numbers of equipment suppliers, Contractors, General Contractors, Architect and Engineer.

.6 Provide shop drawings of each manufactured item.

.7 Operating instructions shall include:

a) General description of each mechanical system.
b) Step by step procedure to follow in putting each piece of equipment into service.

c) Schematic control diagrams for each separate system. Each diagram shall indicate locations of start-stop switches, insertion thermostats, thermometers, freezestats, firestats, pressure gauges, automatic valves, and accessories. Correct operating settings for each control device shall be indicated on diagram.

d) Drawings of each control panel identifying all components on the panels and their function.

e) All mechanical equipment wiring diagrams.

.8 Maintenance instructions shall include:

a) Manufacturer's maintenance instructions for each item of mechanical equipment installed under this Division. Instructions shall include installation instructions, parts numbers and lists, name of supplier and maintenance and lubrication instructions.

b) Summary list of each item of mechanical equipment requiring lubrication, indicating the name of the equipment item, location of all points of lubrication, type of lubricant recommended, and frequency of lubrication.

.9 Testing and Balancing Report

a) Air and Hydronic Balancing Report

b) Hydrostatic Test Certificates

c) Sprinkler Contractors' Test Certificates

d) Chemical Treatment Test Report

e) MOEE Certificate

f) Boiler Certificate

g) Smoke Control testing Report

1.10 **STORAGE OF MATERIALS**

.1 Proper facilities for storage and protection of material and equipment shall be provided at the job site.

.2 All pipe to be used on the job shall be carefully stacked off the floor with ends capped or suitably plugged to prevent entry of dirt, etc. All openings in pressure vessels, tanks, etc., shall similarly be kept closed until ready for use.

1.11 **CO-OPERATION OF TRADES**

This Contractor is to co-operate with all other trades on the job, so that all equipment can be satisfactorily installed, and so that no delay is caused to any other trade.

1.12 **GUARANTEE**

.1 This Contractor will guarantee products and execution of work under this Division against defects of material and workmanship for two full years after date of final acceptance. Provide 5 year warranty for all compressors.

.2 Repair defects that are discovered or develop during this period and make good any resulting damage to equipment or building. Repairs to be carried out at no cost to Owner.

1.13 **EXTRAS AND CREDITS**

.1 Submit prices for extra work, or work to be deleted, with a complete breakdown as follows:

a) Quantities of all major items of equipment and material and total price.

b) Total material cost.

c) Total man hours.

d) Total labour

e) Total overhead and profit.

1.14 **Commissioning**

.1 Beside standard testing and commissioning, certain equipment and system will require special procedure. These equipment and systems are specified in Section 15995. The contractor is responsible to execute the commissioning process which will be directed by a commissioning authority whose services will be provided by owner.

PART 2 - PRODUCTS.

2.1 **MATERIALS**

.1 Materials and equipment are specifically named and described in this specification to establish a standard to which this Contractor shall adhere. Where one or more Manufacturer's names are used to describe materials or equipment, the Contractor shall tender on the material or equipment specified.

.2 Items of equipment of the Contractor's choice may be offered as alternatives to the items named in the specifications. The Contractor shall state in his tender the amount of the addition or deduction from the base bid if the alternatives are accepted. The Owner reserves the right to accept or reject an alternative without explanation.

.3 The Contractor shall assume full responsibility that the equipment offered as an alternative is suitable for the space allocated and for any additional costs to any part of the work resulting from the acceptance of the alternative, such as larger motor starters, larger power feeders, controls, structural requirements and etc.

.4 Contractor shall notify if any extended delivery time is required for this substitution.

2.2 **SHOP DRAWINGS**

.1 All equipment shall be subject to review by the Engineer and no deviation from plans and Specifications will be allowed unless written consent is first obtained. Six certified prints of each major item of equipment are to be submitted for review. The checking of shop drawings shall not relieve the contractor from the responsibility for their accuracy, nor for departures from the Contract drawings or specifications.

2.3 **ACCESS DOORS**

.1 This Contractor shall supply access doors of adequate size wherever any equipment, valves, dampers, etc., are built in or concealed behind walls, or ceiling. Doors to be installed by General Contractor. Coloured thumb tacks shall be used in acoustic tile ceilings.

.2 Access doors shall be Le Hage L1101, 12 U.S.S. gauge steel with concealed hinges, anchor straps, screwdriver operated lock, rounded safety corners and dust tight doors that open 180 degrees. Doors to be adequately sized to suit equipment which is to be accessed.

.3 In acoustic tile ceiling, where access cannot be achieved through tile, installs Le Hage L1006 access doors to suit tile. Markers to be approved colour-coded markers to indicate type of valve or equipment concealed.

.4 Where access doors are to be installed in a fire rated assembly, the access door must have a fire rating equal to or greater than the assembly fire rating.

2.4 **SUPPORTS**

.1 This Contractor shall furnish and install all special structural work required for the installation of pumps and motors, etc. All details shall be to the approval of the Engineer and drawings shall be submitted for all major steel supports. All floor mounted equipment shall be set at least 100 mm above the floor on concrete bases, and anchored securely with anchor bolts. Bases and anchor bolts to be provided by this trade.

.2 Where on the drawings or specifications special isolation bases are noted, these shall also be the responsibility of this trade.

.3 All equipment shall be properly aligned on bases before being bolted down.

2.5 **ELECTRIC MOTORS AND WIRING**

.1 Unless noted otherwise - Motors to have the following characteristics:

373W and under, 120 volt, 60 cycle, single phase
560W and up, 208 volt or 575 volt, 60 cycle, three phase.

As indicated on plans and equipment schedules.

.2 All motors required for this Contract shall be supplied by this Contractor.

.3 Provide motors of adequate size and type for intended service. Unless stated otherwise, use ambient temperature of 40 deg.C.

.4 All motor 1 HP or larger shall be high efficiency type as per ASHRAE 90.1 requirement.

2.5A **MOTOR STARTERS**

.1 This contractor shall furnish all starters for mechanical equipment.

,2 Starters to be combination type with Type J fuses.

.3 Starters for equipment served by emergency power systems shall be reduced voltage type with Type J fuses.

2.6 **SPECIAL TOOLS AND SPARE PARTS**

.1 Furnish spare parts as follows:

a) One set of mechanical seals for each pump.
b) One casing joint gasket for each pump.
c) One head gasket for each heat exchanger.
d) One glass for each gauge glass installed.
e) One set of V-belts for each piece of machinery.
f) One set of filters for each filter bank installed.

.2 Identify spare parts containers as to contents and replacement parts number.

.3 Provide one set of special tools where required to service equipment as recommended by manufacturers.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 EXCAVATION AND BACKFILLING

a) This Contractor shall provide all excavation and backfilling necessary for all installation of work of this Mechanical Division and comply with requirements of Codes, Bylaws, and bodies having jurisdiction over installation of work.

b) Bottoms of trenches shall be excavated so to piping, conduits, ducts, etc., will be supported on a solid bed of undisturbed earth with additional excavation under joints to permit joint to be properly made up. Provide a concrete pad, brick or concrete piers properly reinforced under all piping, etc., below grade when a solid undisturbed earth is not obtainable.

c) Bed beneath pipe shall be laid of approved sand supplied and consolidated to provide a continuous solid bearing for the pipe. Do all necessary pumping required to maintain any excavation free of water.

d) All backfilling inside of building, under sidewalks, paved areas and roads shall be done with pit run gravel or sand in 305 mm layers, thoroughly compacted without use of puddling or flooding with water. Manual compaction up to 457 mm above pipe shall be carried out then mechanical compaction, using approved equipment for balance to obtain a 95% Modified Proctor density up to grade level.

.2 SLEEVES, HOLES AND PATCHING

a) Provide cutting and patching as specified under the General Conditions and Supplementary General Conditions bearing in mind that the integrity of the fire separations is to be maintained at all times.

b) Supply and set all necessary sleeves for this contract prior to pouring of concrete.

c) All holes, pipe chases, etc., shall be large enough to accommodate the thickness of insulation specified.

d) Holes through concrete structural members shall have schedule 40 steel pipe sleeves; other sleeves may be light gauge galvanized steel.

e) Provide for cutting of all holes for piping etc. in precast concrete panels in locations approved by Architect.

f) Holes through structural steel be reinforced with steel plates welded each side, to a design by the Engineer.

g) Holes through walls and roof are to be properly flashed and made weatherproof, see Architectural drawings for details.

h) Inform the General Contractor of any holes required in walls, floors or roof.

i) All cutting and patching and drywall required by mechanical trades shall be done by the General Contractor, but cost provided for under this Section.

j) Sleeves for un-insulated pipes shall be sized to allow 13 mm clearance between the pipe and the sleeve.

k) Sleeves through foundation walls shall have the 13mm space sealed with non-

hardening sealant to make the sleeve waterproof.

l) Sleeves in potentially wet floor areas shall extend at least 25 mm above the finished floor.

m) Pipes shall not be in direct contact with plaster, concrete or any other finishing material.

n) Pipes passing through sleeves in firewalls and fire-rated ceilings shall have 13mm space between the pipe and the sleeve caulked with approved high temperature insulation cement to avoid smoke and sound transmission.

o) Pipes passing through walls and floors that are not fire-rated shall have the 13 mm space between the pipe and the sleeve caulked with insulation and/or insulation cement to avoid sound, smoke and dust transmission. Fire stop system shall be manufactured by `Instant Firestop Manufacturing Inc.'. Fire stop system shall be approved by underwriter's laboratories, inc. and shall include #305-SL, #344-GG silicone, #C1000 motor and type MV mineral wool.

p) Where mechanical equipment is installed in a fire-rated assembly provide fire dampers, drywall enclosure or other as required to maintain the assembly fire rating to the approval of the Engineer. Include all costs.

.3 WORKMANSHIP

a) Employ a responsible foreman to supervise the work and retain this foreman on the job throughout the construction period until completion of work, unless otherwise approved or directed by Engineer.

b) Employ only skilled plumbers, steam fitters, sheet metal workers for execution of work. Workmanship shall be first class not only as regards durability, efficiency and safety, but also as regards to neatness of detail.

c) Set equipment accurately, plumb and level and align hanger rods and steel supporting structures.

.4 PIPING

a) All pipes for this Division shall be run concealed in finished areas where possible and grouped so that valves, etc., are accessible through as few access panels or doors as possible, but still maintaining working space.

b) In specifically designated unfinished areas such as mechanical rooms, run pipes neatly parallel or in banks and group valves. Piping may run exposed in these designated areas. The crossing over of pipes must be kept to a minimum.

c) Piping that does not present a neat workmanlike appearance, in the opinion of the Engineer, shall be reworked according to his instructions without extra cost to the Owner. Piping within pipe chases that have been designed for access of personnel shall be arranged so that access is not impaired.

d) The piping shown on the drawings is located diagrammatically in the space in which it is intended to run, but co-operation and co-ordination of the work of other Divisions, also installing pipes, conduits, ducts, etc., within the same area must be exercised. No extras will be paid for any relocation of piping to suit the work of other Divisions.

e) Separation by approved dielectric unions shall be applied to all ferrous and non-ferrous piping. All connecting or touching metals that could give rise to electrolytic

action must be separated by insulation.

f) All piping shall be installed with adequate change of direction, expansion joints and anchors, so that the piping and equipment will in no way be strained or distorted by expansion and contraction.

g) If on the job circumstances require additional change of direction and expansion loops, furnish and install same at no extra cost.

h) All take-offs from the mains shall be made using swing joints wherever possible.

i) Anchors shall be provided where necessary to protect equipment and shall generally be made from 13 mm M.S. plate with structural steel angle and channel sections.

j) Suitable anchors and guides shall be provided where shown or where necessary for all expansion devices.

k) Expansion loops shall be located midway between anchors except where shown otherwise. All expansion loops shall be cold sprung 50% in accordance with the latest edition of the ASHRAE Guide.

.5 IDENTIFICATION OF PIPING

a) Identify all visible piping whether fully exposed or in accessible spaces such as above lay in ceilings.

b) Identify the medium in the piping with legend, lettering and direction-of-flow arrows of indicated colour on a field colour "patch" as indicated in the following table:

Medium In pipe	Legend Lettering & Flow Arrows	Legend Lettering & Flow Arrows	Field Colour "Patch" Colour
Cold Water	C.W.	Black	Green
Domestic Hot Water	D.H.W.	Black	Green
Domestic Hot Water Recirc.	D.H.W.R.	Black	Green
Sanitary Sewer	San.	Black	Green
Storm Sewer	R.W.L.	Black	Green
Plumbing Vent Pipe	V.P.	Black	Green
Natural Gas	Gas	Black	Yellow
Stand Pipe System Water	S.P.	White	Red
Sprinkler System Water	S.W.	White	Red
Steam Supply	S	Black	Yellow
Steam Condensate	S.C.	Black	Yellow
Coil Condensate	C.C.	Black	Green
Condenser Water Supply	C.W.S.	Black	Green
Condenser Water Return	C.W.R.	Black	Green
System Water Supply	S.W.S.	Black	Green
System Water Return	S.W.R.	Black	Green

c) All piping identification shall be done by the mechanical contractor with painting and surface preparation to comply with Division 9.

d) Location:

1) Locate markers and classifying colour on piping systems so they can be seen from floor or platform.

2) Identify piping runs at least once in each room.

3) Do not exceed 8 meters between identifications in open areas and above T-bar ceilings.

4) Identify both sides where piping passes through walls, partitions and floors.

5) Where piping is concealed in pipe chase or other confined space, identify at point of entry and leaving, and at each access opening.

6) Identify piping at starting and ending points of runs and at each piece of equipment.

7) Identify piping at major manual and automatic valves immediately upstream of valves. Where this is not possible, place identification as close to valve as possible.

8) Identify branch, equipment or building served after such valve.

.6 IDENTIFICATION OF DUCTWORK

a) Stencil over final finish only.

b) Use 50 mm high black stencilled letters, e.g. "Supply", "Return", "Toilet Exhaust", "Kitchen Exhaust" with directional flow arrows.

c) Maintain 8 meters maximum distance between markings.

d) Identify ducts each side of dividing walls or partitions and beside each access door.

.7 IDENTIFICATION OF EQUIPMENT

a) Provide laminated plastic plates with black face and white centre of minimum size 90x40x2 mm nominal thickness, engraved with 6 mm high lettering. Use 25mm lettering for major equipment.

b) Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.

c) Identify equipment type and number and service or areas or zone of building served.

3.2 **MANUFACTURER MANUAL**

.1 All work shall be in accordance with manufacturer installation and operation manual. (e.g. drain, insulation, vibration isolation and etc that might not be shown in the drawing.)

3.3 **PLACING IN OPERATION**

.1 Prior to acceptance and on completion of work, there shall be made a complete operational test of systems and work carried out under Mechanical Division.

.2 At all fixtures, adjustments for correct water flow shall be made, this to include hot and cold water system and flush valves.

.3 All drains, covers and gratings are to be removed and cleaned, traps cleaned out and drain thoroughly flushed through.

.4 All strainers are to be cleaned out after two weeks of normal operation.

.5 All filters in fan cabinets are to be removed, thoroughly cleaned and stored for future use.

New filters shall then be placed in units. Bird and insect screens on all louvres shall be cleaned.

.6 All tests and balancing works must be carried out by a current member in good standing of the Canadian Chapter of Associated Air Balance Council. Design test, Dynamic Flow Balancing are approved balancer.

3.4 **START-UP SERVICE**

.1 Services of a qualified technician shall be provided and they shall be responsible for assisting Owner's staff in becoming familiar with operation of systems, acting on any complaints from Owners, Architect or Engineer regarding operation of any of the systems.

.2 In general ensures that last minute adjustments of systems are carried out promptly and with a minimum of inconvenience to Owner.

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

Conform to the General Provisions of Section 15010.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- Insulation Section 15180
- Heat Transfer Section 15700

1.3 QUALITY OF ASSURANCE

a) Requirements of Regulatory Agencies

.1 Conform to local and district by-laws, regulations and published engineering standards.

.2 Conform to Plumbing Code, Ontario Regulations 647 under the Ontario Water Resources Act.

.3 Conform to Building Code, Ontario Regulation 925 under the Building Code Act.

.4 Conform to ACNBC Canadian Plumbing Code, Current Edition.

.5 Conform to Regulations for Construction Project, Ontario Regulations 659 under the Occupational Health and Safety Act, Current Edition.

.6 Conform to regulations of Natural Gas and Propane Installation Code CAN/CSA-B149.1, Current Edition.

.7 Ontario Regulation 212/01 under the Technical Standards and Safety Act.

.8 CSA Standards.

.9 ASME Boiler and Pressure Vessel Code.

.10 ASHRAE Standards.

.11 MNECB Standards.

b) Material standards:

.1 CAN/CSA-B51-[M1991], Boiler and Pressure Vessel Code.

.2 ASTM A53-[90a], Black Steel Pipe Flanges and Flanged Fittings.

.3 ANSI/ASME B16.3-[1985], Cast Iron Pipe Flanges and Flanged Fittings.

.4 ANSI/ASME B16.3- [1985], Malleable Iron Threaded Fittings.

.5 ANSI/ASME B16.5-[1988], Steel Pipe Flanges and Flanged Fittings.

.6 ANSI/ASME B16.9-[1986], Steel Buttwelding Fittings.

.7 CSA B242-M1980, Groove Type Mechanical Pipe Coupling.

.8 CGSB 14-GP-2a, Direct Reading Thermometers

.9 CGSB 91-GP-3, Dial Type Pressure Gauges.

.10 CGSB 51-GP-9M-[76], Rigid Mineral Fibre Insulation.

.11 CGSB 51-GP-52Ma-[89], Vapour Barrier Jacket.

.12 CAN/CGA-B149.1-[00], Natural Gas Installation Code.

.13 ASTM A516/516M-[90], Carbon Steel Pressure Vessel Plates.

.14 ASME Section VIII for Unfired Pressure Vessels, [1992].

.15 CAN/CSA-B52-[99], Mechanical Refrigeration Code.

.16 ASTM B306-[88], Copper Tube Type DWV.

.17 CAN/CSA-B125-[M89], Wrought Copper Drainage Fittings.

.18 CAN/CSA-B70-[M91], Cast Iron Soil Pipe

.19 ASTM B88M-[92], Seamless Copper Water Tube.

.20 ASTM F1476-[07], Standard Specification for the Performance of Gasketed Mechanical Couplings for Use In Piping Applications.

.21 ANSI B16.22-[1989], Wrought Copper Fittings.

.22 CGSB51-GP-11M-[78], Mineral Fibre Blanket.

1.4 **SUBMITTALS**

.1 Submit shop drawings in accordance with Section 15010 paragraph 2.2 for all equipment items.

.2 Grooved joint couplings and fittings may be shown on drawings and product submittals, and shall be specifically identified by the manufacturer's style or series designation.

PART 2 - PRODUCTS

2.1 **PIPE AND PIPE FITTINGS (NO ASBESTOS MATERIALS ALLOWED)**

a) System, Chilled and Heatintg Water Piping.

.1 Steel pipe 50mm and smaller - schedule 40, electric weld or seamless A.S.T.M.

.2 Steel pipe 65mm and larger - schedule 40, electric weld or seamless A.S.T.M. Specification A-53 with butt welding ends.

.3 Stainless steel pipe, 50mm and smaller – schedule 10S, Type 304/304L [316/316L], A.S.T.M. A-312 with plain ends for use with the Vic-Press piping system.
Vic-Press for Schedule 10S pipe fittings shall be precision, cold drawn, stainless steel with elastomer O-ring seals, suitable for water pressures to 500-psig CWP, with a Victaulic Series PFT-510 tool with the proper sized jaw.

.4 Copper pipe 50mm and smaller - Type "L" hard drawn copper with wrought copper solder type fittings.

.5 Dielectric unions to be used between copper and steel pipe.

.6 Steel pipe fittings up to and including 50mm shall be threaded joints malleable iron type.

.7 Steel pipe fittings 65mm and larger shall be forged steel butt welding type with all joints welded.

.8 All elbows shall be long radius type.

.9 Copper pipe fittings to be wrought copper or cast bronze solder type.

.10 Victaulic-Systems are acceptable equals for steel pipe and copper tubing as specified herein.

Fittings for Steel Piping: A.S.T.M. A-536, Grade 65-45-12, ductile iron; A.S.T.M. A-234, Grade WPB wrought steel; or factory fabricated from steel pipe conforming to A.S.T.M. A-53.

a. Fittings for use with copper tubing shall be manufactured to copper-tubing sizes. (Flaring of tube or fitting ends to accommodate alternate sized couplings is not permitted.) Fittings shall be wrought copper to A.S.M.E. B16.22, or cast bronze to A.S.M.E. B16.18. Victaulic Copper-Connection.

Grooved joint couplings shall consist of two ductile iron housing segments to ASTM A536, pressure responsive gasket to ASTM D2000, and zinc electroplated steel bolts and nuts to ASTM A449. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use In Piping Applications.

a. Rigid Type: Coupling housings shall be cast with offsetting, angle-pattern bolt pads to provide joint rigidity and support and hanging in accordance with ANSI B31.1 and B31.9.
   1) Victaulic Style 107H, Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 deg F.
   2) Victaulic Style 07 “Zero-Flex”

b. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Victaulic Installation-Ready Style 177 or Style 77.

c. 14” and Larger: AGS Series, with lead-in chamfer on housing key and wide width FlushSeal gasket. Victaulic Style W07 (rigid) and Style W77 (flexible).

d. Couplings for copper tubing shall be manufactured to copper-tubing sizes, with offsetting angle-pattern bolt pads. Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket, suitable for water service to +250 deg F. Victaulic Style 607H.

b) Sanitary Drain Storm Drain & Vents

.1 Above Ground - Storm and waste pipe 75mm and over to be medium weight cast iron type MJ, unless indicated otherwise; 65mm and under copper DWV pipe and fittings.

.2 Vent pipe 75mm and up shall be medium weight cast iron type MJ; 65mm and under DWV copper. Buried vent pipe 40 mm and smaller to be type ' L ' copper.

.3 Below Ground - PVC or Cast iron soil pipe to CAN/CSA - B70 with cast iron fittings, hub and spigot joints or mechanical joints, and heavy bituminous coated.

c) Domestic Water Piping

.1 Domestic water lines above grade shall be type L. copper

.2 Domestic water lines below grade to be type K seamless copper tubing without joints. All fittings to be wrought copper or cast bronze.

.3 Exposed piping in finished areas shall be chrome plated.

.4 Grooved joint couplings for copper tubing shall be manufactured to copper-tubing sizes, with offsetting angle-pattern bolt pads. Installation-Ready, for direct stab installation without field disassembly, with grade EHP gasket, UL classified in accordance with ANSI/NSF61 for Potable Water service. Victaulic Style 607H.

d) In-Suite Domestic Water Piping

.1 `WIRSBO' Plumbing pipe (red or blue) for hot and cold water applications shall be rated for 200 psi at 73° and 100 psi at 180°F. Pipe and fittings shall be certified to CSA B 137.9 and to NSF standards 14 and 61. Pipe is listed with astm for CL-TD rating.

.2 The pipe and fittings shall have the following markings:

ASTM F 1282
CSA B 137.9
Pipe Size
Material Type
Pressure rating - 200 psi at 73°F and 100 psi at 180°F
Manufacturer's date and material code
Flame spread and smoke developed classification
Fittings shall have the following:

Manufacturers name and trademark
Mark of certification agency
If size permits ASTM F 1974
CSA 137.9 Brass CSA 137.9 and Plastic B 137.10

.3 Sizing

Normal Pipe Size	Minimum Average ID
2"(12mm)	0.50" (12.7mm)
3/4" (20mm)	0.806 (20.5mm)
1" (25mm)	1.032 (26.2mm)

.4 Flame Spread and smoke Development
Composite pipe shall be listed by a third party certification agency to show a flame spread rating of (5) and a smoke developed classification of (25) where the tests methods are to CAN/IULC S 102.2. This shall be marked on the pipe.

.5 Fire Stopping
When composite pipe penetrates a fire separation use firestop products and methods that are listed by ULC as per CAN-S-115.

.6 Thermal Expansions
The pipe shall have a linear expansion rate of no more than 1.56 inches per 100 feet of pipe per 100°F changes in temperature.

.7 Installation
- The pipe may be supported every 8 ft. 2" (2.5 meters) in the Province of Ontario.
- Minimum bending radius shall be 5 times the nominal pipe diameter.
- The grounding of electrical systems to XPA pipe is not permitted.

.8 Ontario Building Cod (OBC) Requirements
Pipe shall exhibit a Flame Spread Rating of not more than 25 and a Smoke Developed Classification not more than 50 when tested using the procedures of ULC/CAN4-S102.2M. Testing shall be conducted by a certified test laboratory and a listing shall be held which includes all available sizes of tubing. Actual Flame and Smoke Ratings shall be printed on pipe exterior for ease of inspection.

Pipe meeting the above OBC requirements may be used in Air Plenums, High Rise Construction and all other classifications of commercial construction, either exposed or concealed. Pipe shall not be permitted for use in Vertical Shafts.

.9 High Rise Slab Construction
Each residential suite shall contain a minimum of one hot water and one cold water 3/4" diameter copper header with 12 mm (2") nominal sized branches suitable for crimp connection to the composite piping as described above. Piping from the headers shall supply all fixtures in the suite. Headers shall be certified to CSA B137.9 or B137.10.

Water piping shall have a rate of expansion-contraction no greater than 1.3 x 15^5 in./in./EF (0.23 mm10 m/EC). Pipe, fittings and headers to be supplied from the same manufacturer, IPEX Inc. or approved equal.

.10 Testing and Flushing
Testing may be done in any temperature. Testing can be performed with water or air. Water or air testing shall be 50 psi over the city pressure for a minimum of 1 hour with no leakage. The system must be thoroughly flushed after testing.

.11 All installations are to be done to the manufacturers specifications.

e) Gas Piping

.1 Pipe to be black steel schedule 40 to ASTM A 53 and according to Enbridge=s standard.

.2 Valves to be C.G.A. certified, plug cock type installed where shown or required with one for each appliance.

.3 Fitting to be schedule 40 steel buttwelding.

2.2 HANGERS & SUPPORTS

.1 Hangers shall be carbon steel with copper or plastic coating for direct support of copper tubing, and shall be carbon steel with black corrosion resistant finish for all other piping.

.2 Use Grinnell FIG 65, 70, 97, CT-99, 101, 260, or 269 hangers for individual support of all horizontal piping.

.3 Provide pipe covering protection saddles at each hanger where pipes are insulated.

.4 Where spring hangers are indicated, use Grinnell Fig. 171 single pipe roller and Fig. 178 Spring cushion hanger.

.5 Pipe rollers shall be selected to match pipe saddles.

.6 Use 100mm x 38mm minimum steel channel for joint support of horizontal piping.

.7 Use welded beam attachments or beam clamps for support of horizontal pipe from steelwork.

.8 Perforated pipe hangers are not acceptable.

.9 Support gas piping on roof on creosote impregnated wood blocks. See detail on Architectural drawings.

.10 Hangers and supports shall be as manufactured by Grinnell, Myatt or Economec.

2.3 VALVES AND ACCESSORIES

Please refer to riser diagram for pressure rating of each zone.

.1	Domestic Water	150 psi	300 psi
	a) Gate Valves:		
	i) Up to 50mm screwed and/or soldered:	Crane 438 and 1320 Jenkins 310 and 313 RW/Toyo 280A and 281A Newman Hattersley A40AT and A41SE	KITZ 37 screwed
	b) Ball Valves:		
	i) Up to 50mm screwed and/or soldered:	RW/Toyo 5044A, 5049A Watts B6000, B6001 KITZ 58 & 59	KITZ 58 - 59
	ii) Up to 50mm VicPress ends	Victaulic P589 (Brass body); 300 psi Victaulic P569 (Stainless steel body); 400 psi	
	c) Butterfly Valves:		
	i) 65mm thru 150mm grooved	Victaulic Series 608; 300 psi	
	d) Swing Check Valves:		
	i) Up to 65mm screwed and/or soldered:	Crane 37 and 1342 Jenkins 4092 and 4093 RW/Toyo 236 and 237 KITZ 22 & 23	KITZ 19
	ii) 75mm and larger flanged:	Crane 373 Jenkins 587 RW/Toyo 435JA	

			KITZ 78	
.1	Domestic Water		150 psi	300 psi
	d)	Shock Absorbers:	Ancon-Shokgard Enpoco-HT Series Zurn- Shok Trol	KITZ 300 SCLS BERIC 103-RF- AA08-H
	e)	Drain Cocks:	Emco 10240 Cambridge Brass 32W 200	
.2	System Water		150 psi	300 psi
	a)	Gate Valves:		
		i) Up to 50mm	Crane 428 Jenkins 810 RW/Toyo 293 KITZ 24	KITZ 37
	b)	Butterfly Valves:		
		i) 75mm and over, lever operated:	Crane 55x4 EL Jenkins 2232 EL KITZ 6122EL Victaulic Vic300 MasterSeal; 300 psi	WKMB5313-02 - S02-11-HL
		ii) 200mm and over, gear operated	Crane 55x4 EG Jenkins 2232 EG KITZ 6122EG Victaulic Vic300 MasterSeal / AGS-Vic300; 300 psi	WKMB5313-02 - S02-11-WG
		Note: Stem on butterfly valves for hydronic water services shall be offset from the disc centerline to provide complete 360-degree circumferential seating.		
	c)	Check Valves:		
		i) Up to 50mm	Crane 37 Jenkins 4092 RW/Toyo 236 KITZ 22	KITZ 19
		ii) 65mm and over:	Crane 373 Jenkins 587 RW/Toyo 435JA KITZ 78 Victaulic Series 716; 300 psi / Series W715; 230 psi	KITZ 300 SC0S BERIC 303-RF- EA08-X
	d)	Ball Valves:		
		i) Up to 50mm (Full Port)	RW/Toyo 5044A Watts B6000 KITZ 58	KITZ 58
		ii) Up to 50mm VicPress ends	Victaulic P569 (Stainless steel body); 400 psi	
	e)	Flow Balancing Valves:	Victaulic/ TA Hydronics Series 787 / 789	

Armstrong CBV
Tour & Anderson
STA Taco 790 Series.
Bell & Gosset CB

f) Coil-Hook-up Connections: Victaulic Koil-Kits Series 799 or 79V may be used at the contractors option for coil connections. The kit shall include a Series 786/787/78K circuit balancing valve, Series 78Y Strainer-Ball (78T where strainer not required), Series 78U Union-Port fitting and required coil hoses.

g) Differential Pressure Controllers: Valves that are capable of differential pressure control, adjustable Dp, measuring point, positive shut off and circuit drain connection. Provide as indicated on drawings and schematics. Victaulic/ TA Hydronics Series 794 and/or 793 STAP.

h) Differential Pressure Meter: Mechanical Contractor shall supply differential pressure meter from the same supplier as the balancing valves. Meter shall be left for the owner upon completion of the project. Needle type meters will not be allowed.

.3 Strainers

a) Furnish and install strainers where shown on the drawings. Strainer brackets shall be of stainless steel or model selected for the service for which they are installed. Strainers 50mm I.P.S. and smaller shall be screwed; 65mm I.P.S. and larger shall be grooved end or flanged. All flanged strainers shall be provided with a blow-off ball valve, full size of blow-off tapping, with a short nipple on discharge side. Smaller strainers shall have nipple and cap affixed. Strainers to be Victaulic, Meuller, Sarco, Armstrong, Watts, or Red and White/Toyo.

b) Strainer bodies for mechanical systems shall be ductile iron, cast iron, or bronze, rated for water services to 300 psig CWP.

c) Strainer bodies for plumbing systems shall be bronze.

.4 Air Eliminators

a) Air eliminators on systems operating at 35 psi and less shall be Hoffman 790, Maid-O-Mist No.7 Dunham Bush V40A, Sarco 13W or Dole 200.

b) Air eliminators on systems operating up to 60 psi shall be Maid-O-Mist No.71, Dunham Bush V40A, Sarco 13W or Dole 75.

c) Air eliminators shall be connected to air collecting chambers with 12mm I.P.S. nipple and isolating gate valve.

.5 Flexible Connectors (Pumps)

a) Connectors shall be Flexonics Standard Braided Flex-Con.

b) Sizes up to 100mm diameter, phosphor bronze hose. 125mm diameter and over, stainless steel hose.

c) Acceptable products: Hydro Flex.

d) Three grooved joint (Victaulic) couplings may be used in lieu of a flexible connector at equipment connections to accommodate vibration attenuation and stress relief. The couplings shall be placed in close proximity to the source of the vibration.

.6 Pressure Gauges

a) Shall be 112mm dia. black cast aluminum case, black figures on white dial face phosphor bronze tube, brass rotary movement ranges to suit pressure of medium being measured, c/w shut-off cock.

b) Trereice series 600X, Winter or Baker.

.7 Temperature Gauges

a) Shall be 225mm scale, aluminum case, adjustable, industrial type with scale calibrated in deg.F. to suit range of medium being measured, black and white scale. All thermometers to include separable well.

b) Acceptable Products: Trerice BX91403 1/2, Baker or Weiss.

.8 Backflow Preventer:

a) Shall be bronze body construction, stainless steel working parts, integral strainer and durable rubber discs. Maximum emergency backflow temperature 49 deg. C. and maximum pressure of 175 p.s.i. Refer to Drawings for types. Watts Series 9D and No 900 Braukmann BF-290

.9 Expansion Joints

a) For steel pipe shall be self equalizing type with two-ply stainless steel bellows, carbon steel shrouds and internal positive anti-torque device. Flexonics Model H or H3, or Hydro-Flex.

b) For copper pipe shall be self equalizing type with two-ply bronze bellows, all bronze construction and internal positive anti-torque device. Flexonics Model HB or HB3 or Hydro-Flex.

c) Grooved Joint Expansion Fittings:

i. Packless, Gasketed, Slip-Type Expansion Joint: Joint consisting of a carbon steel slip section coated with PTFE modified PPS coating with ductile iron body casing, and grooved ends, suitable for axial end movement to 76.2mm (3”).

ii. Expansion joint consisting of a series of grooved end pipe nipples joined in tandem with flexible type grooved joint couplings. The total joint movement is dependent on the number of couplings used in the joint.

.10 Escutcheons

a) Supply and install chromium plated escutcheon plates on all piping passing through finished walls, floors and ceilings. Where sleeves project above the floor in potentially wet areas, provide chromium plated Grinnell Fig.400 escutcheon.

b) Escutcheon plates shall be installed over the insulation and shall have set screws or clamping devices to keep the escutcheon plate in place.

.11 Fire Stop

Provide fire stop system as manufactured by `Instant Firestop Manufacturing, Inc'. Fire Stop System shall be approved by Underwriters Laboratories, Inc. and shall include #305-SL, #344-GG silicone, #C1000 Motar and Type-MW Mineral Wool. All installation shall be in accordance to manufacturer's instruction.

PART 3 - EXECUTION

3.1 PIPING INSTALLATION

.1 System Water Piping.

a) Make all piping connections to fan coil units, etc, and valves to be located so that removal of units and equipment is possible without disconnecting more than a minimum of pipework, or shutting down any other pieces of equipment.

b) Provide adequate space around piping to facilitate application of insulation.

c) All reductions in pipe size to be made with eccentric fittings. Minimum size of runout to be 20mm

d) All vertical FCU risers shall be supplied with the FCUs. Install risers per manufacturer=s instruction.

.2 Storm, Sanitary and Vent Piping

a) Install sanitary drains and connect to fixtures where shown. Carry main drain to a point as shown on drawings. Connect up all drains to drain, open hub or other approved locations. Connect to drainage system all drains from equipment supplied under other Sections.

b) Horizontal sanitary drains shall have the following minimum slopes.

- Fixture waste or drains 2%
- Drains up to and including 75mm 2%
- Drains over 75mm 1%

c) Provide minimum 3M separation when connecting the main sanitary and its auxiliary riser.

d) Connect storm drains to all roof hoppers, canopy drains, etc. Carry main drain to a point as shown on drawings.

e) All fixtures shall be vented in accordance with Local and Provincial Regulations. Vents shall be run as directly as possible and shall be properly graded so as to drain back to fixture connection. Vents shall be concealed in walls, and ceilings; vent stacks shall be built into pipe chases, concealed areas, and walls, with particular attention paid to building frame construction. The bottom of all vent stacks shall be connected into soil stacks for drainage.

f) The only exposed vent pipe or vent stack allowed will be in the areas provided in pipe spaces, mechanical rooms, boiler rooms, etc. Vent stacks shall be carried through roof and shall project a minimum of 12" above roof deck. Co-ordinate this work with roofer for openings in the roof. Assure that stacks are connected to sleeves and properly caulked. Provide Yoke Vent at every five storeys or as required by code.

g) Provide chrome plated brass to all exposed water piping, drains etc in bathrooms and other occupied areas.

.3 Domestic Water Piping

a) Connect hot and/or cold water to all fixtures, hose bibbs, as required and as shown. This shall include all connections to equipment and units supplied under other Sections.

b) All equipment shall have unions or flanged connection for equipment removal and piping shall run concealed in all walls and ceiling but may run exposed in fan rooms and mechanical rooms.

c) Install shock absorbers ahead of all solenoid valves, flush valves or other quick closing valves and where shown. Vacuum breakers shall be installed on all fixtures where required by the Ontario Building Code, or Local Plumbing Inspector.

d) Provide air cushion min. 450 mm for each group of Plumbing fixtures or remotely located Plumbing Fixtures.

e) Provide gate valves at each piece of plumbing equipment and at each line take off, and globe valves where balancing is required.

f) Provide expansion chambers for each kitchen sink.

.4 Gas Piping

a) Complete installation to conform to the latest edition of the gas code including the colour coding of the pipe which shall be by this Contractor to the satisfaction of the Architect.

b) All gas piping to be welded.

c) Slope the piping towards low points or risers, low point drips to have tee, nipple and cap.

d) Test Natural Gas Systems with Nitrogen gas at 690 kPa for 48 hours and carry out repair work as required.

.5 Equipment Connection

Install unions and/or flanges to connect piping to all pieces of equipment. All equipment shall have isolating valves for equipment removal.

Unions and flanges for servicing and disconnect are not required in installations using grooved joint couplings. (The couplings shall serve as disconnect points.)

.6 Flashing

All vent stacks and soil stacks shall connect to extensions, carried through roof by roofing contractor. All holes through roof are to be properly flashed and made weatherproof by roofer as required.

.7 Flushing and Cleaning

a) After pressure tests are completed and approved, prior to start-up and placing into

operation, flush and clean out piping systems.

b) For water and oil systems fill with solution of water and approved non-foaming, phosphate free detergent. Circulate solution throughout piping systems.

c) Flush and drain systems until free of dirt, sludge, oil, grease and other foreign material. Clean strainers.

d) Refill water systems with clean water.

e) Use compressed air to remove moisture from interior surfaces of fuel oil piping systems before filling with oil.

3.2 **PIPING JOINTS**

.1 Threaded Joints

a) Pipe shall be cut at right angles and reamed to full bore.

b) Threads shall be carefully cut with sharp dies and proper cutting oil.

c) All chips and other foreign matter shall be removed from the pipe before installation into system.

d) Proper joint compound shall be used on male threads only. A good grade of hemp fibre shall be used on threads.

e) Connections to be made with proper wrench to suit pipe size, additional leverage will not be allowed.

f) If threaded joints leak after assembly by normal methods, they shall be disconnected and corrected if possible, or replaced. Over tightening or caulking will not be considered a proper correction.

.2 Solder Joints

a) Pipe shall be cut at right angles, reamed, burred and sized.

b) End of pipe and inside of fittings to be cleaned with steel wool to a bright metallic finish.

c) Flux to be applied to outside of pipe and inside of fittings; fitting to be revolved on pipe to ensure proper distribution of flux.

d) Using solder wire, heat assembly with torch until solder has flowed completely around fittings. Wipe off excess solder. Use solder of lead free composition. Larger size pipe joints shall be completely tinned before assembly.

e) Make joints with 95 : 5 antimonial tin solder.

.3 Grooved Joints:

a) Install in accordance with the manufacturer's written recommendations.

b) Grooved ends shall be clean and free from indentations, projections, or roll marks.

c) The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service.

d) The coupling manufacturer's factory trained representative shall provide on-site training for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)

.4 Cast Iron Joints

Mechanical joint cast iron piping and fittings will be assembled in accordance with Manufacturer's recommendations.

3.3 **HANGERS AND SUPPORTS**

.1 Horizontal piping shall be supported as close as practical to the connected equipment and intermediate hangers shall be spaced as follows:

Pipe Size	Maximum Spacing Copper	Steel
Up to 20mm	1.5m	1.8m
12mm to 38mm	1.5m	3.0m
50mm & 65mm	3.0m	3.0m
75mm & 100mm	3.0m	4.5m
150mm & 200mm	3.0m	5.4m

.2 Cast Iron Piping shall be supported at intervals not exceeding 1.5m with clevis hanger securely anchored to building.

.3 Cast Iron Fittings shall be supported at intervals not exceeding 90cm.

.4 Cast Iron pipes shall be supported at every floor.

.5 No support or hanger securing device shall penetrate waterproofing roof membrane above steel deck.

.6 Provide roller supports, floor stands, wall brackets, etc. for all lines running near the floor or near the walls, which can be properly supported by the floors or walls.

.7 All pipe support arrangements shall be adjustable for proper support and grading.

.8 Suspend piping using malleable iron or wrought steel hangers suspended from hanger rods threaded each end not more than 300mm. Continuous threaded hanger rod may be used in concealed locations only.

.9 Hanger rods shall be attached to concrete inserts, or beam clamps, or welded brackets.

3.4 **VALVES AND ACCESSORIES**

.1 Use valves of line size unless noted otherwise.

.2 Provide isolating valves in each branch from the main line and where shown.

.3 Provide isolating valves for all fixtures, appliances etc. are including the following:

a) On each side of pumps, pressure reducing stations and tanks.

Note: Valves are not necessarily shown on the drawings.

.4 Provide 20mm brass hose bibb at any low point of the system not drainable through the main flow and return piping.

3.5 **TEMPERATURE GAUGES**

.1 Install thermometers in all locations noted.

.2 Check range of temperature expected at each location and supply thermometer with range to suit.

.3 All thermometers to be installed in separable wells.

3.6 **PRESSURE GAUGES**

.1 Install pressure gauges in all locations noted and before and after each circulating pump.

.2 Check range of pressures expected at each location and supply pressure gauge with range to suit.

3.7 **INSPECTION AND TESTING**

.1 Make tests that are required by any authority having jurisdiction, in the presence of the authorities' authorized inspector. Tests are to be certified by him.

.2 Test all piping at the completion of roughing in before connecting to existing systems, and prior to concealment, insulation or covering of piping.

.3 All piping shall be tested in the presence of the Engineer or their authorized representative before any covering up or closing in of piping is done.

.4 All drainage and vent piping shall be tested using water test method before connection of fixtures and shall maintain the required water level for 24 hours.

.5 All water distribution piping shall be tested at a pressure of not less than 150 p.s.i. maintained for 6 hours without necessity of additional pumping.

.6 Any leaks found shall be properly repaired and test reapplied until results satisfactory to the Engineer are obtained.

.7 This Contractor shall notify the Engineer at least 48 hours before he intends to carry out tests.

3.8 **HYDRONIC BALANCING**

The certified testing and balancing contractor shall balance all systems and submit (3) balancing reports to the Engineer also to assist commissioning agent per requirements set in section 15995. Allow in his price for trimming of pump impellers if required.

3.9 **CLEAN-UP**

This Contractor shall avoid accumulation of scrap and debris resulting from his operations and shall at all times keep his working site in a neat and clean condition. On completion of contract he shall remove all scrap and debris resulting from his work and shall clean up all equipment installed by him.

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

.1 Conform to the General Provisions of Section 15010.

.2 Provide work under this Section as shown or specified and in accordance with the requirements of the Contract documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- Plumbing Work Section 15400
- Basic Materials & Methods Section 15050
- Heat Transfer Section 15700
- Air Distribution Section 15800

PART 2 - PRODUCTS

2.1 GENERAL

.1 Insulating materials by Owens Corning (Fiberglass) is the basis for the description of type and quality of material required.

.2 The equal products of the following manufacturers will be accepted: Canadian Johns-Manville, Atlas Asbestos Company.

.3 For adhesives and mastics for applications noted equal products of the following manufacturers will be accepted: Flintkote; Benjamin Foster; Minnesota Mining and Manufacturing.

.4 All insulation materials must be non-combustible, and asbestos free. Vapour barrier jacket, and adhesive to be fire retardant to approved standards of fire hazard classification for building materials. Flame spread rating not to exceed 25 and smoke rating not to exceed 50.

.5 All insulation must comply with ASHRAE 90.1 standard and MNECB table 5.2.2.5, 5.2.4.3 and 6.2.3.1.

2.2 MATERIALS

.1 System Water, heating water, Free Cooling/Chilled Water, Domestic Cold Water and Cold Condensate Piping

a) Piping 25mm, (38mm for heating lines larger than 63mm) Fiberglass heavy density fibreglass insulation with factory applied all service vapour barrier jacket lapped and adhered with Flintkote 203 adhesive or equal. Seal all joints with 100mm wide strip of all service jacket material.

b) Valves, Flanges and Water Meter - Moulded and fabricated segments of a thickness equal to that of the pipe insulation and finished with a layer of asbestos free finishing cement. trowelled smooth and covered with canvas.

c) Exposed insulation - Finish with 220 g/sq.m fire retardant canvas with two coats Benjamin Foster 30-36.

.2 Domestic Hot Water, Recirculation Piping, and Domestic Hot Water Storage Tanks.

a) Piping 25mm, (38mm for DHW lines larger than 63mm) Fiberglass heavy density fibreglass insulation with factory applied all service jacket lapped and adhered with Flintkote #203 adhesive or equal. Seal all joints with 100mm wide strip of all service jacket material.

b) Valves and Flanges - Moulded or fabricated segments of a thickness equal to that of the pipe insulation and finished with a layer of asbestos free finishing cement trowelled smooth and covered with canvas.

c) Exposed Insulation - Finished with 170 gm fire retardant canvas with two coats Benjamin Foster 30-36.

.3 Roof Hoppers and R.W.L.

a) Horizontal R.W.L.'s 25mm Fiberglass standard density Fiberglass as specified for domestic cold water.

b) Base of all roof hoppers insulated with moulded Fiberglass segments of a thickness equal to that of the pipe insulation and finished with a layer of asbestos free finishing cement, trowelled smooth and covered with canvas.

.4 Ductwork

a) External (rigid) - 25mm Fiberglas rigid vapour seal type (RFFRK) in exposed areas finish with 236 gm canvas adhered with fire retardant adhesive. Apply to outside of ductwork.

b) External (Flexible) - 25mm Fiberglas faced flexible duct insulation with factory applied reinforced foil facing. In exposed areas finish with 236 gm canvas, adhere with fire retardant adhesive.

c) Weatherproofing - Apply two 4mm thick coats of asphalt or vinyl mastic to the external type duct insulation, with a glass reinforcing fabric between coats lapping joints a minimum of 300mm.

.5 Piping Exposed to the Weather

a) Insulation shall be 25mm thick Fiberglass and piping shall be wrapped with 23kg roofing felt with a 50mm overlap at longitudinal and circumferential joints. All joints shall be positioned to shed water. Piping to be finished off with .016 mil embossed aluminium jacket with a 50mm overlap at longitudinal and circumferential joints. Secure in place with 20mm x 0.38 mm Aluminium bands on 450mm centres. Care should be taken with the Electric tracing cable which will be located inside the insulation.

PART 3 - EXECUTION

3.1 GENERAL

.1 Do not apply insulating materials until equipment to be insulated has been properly cleaned, dried and tested to the satisfaction of the Architect.

.2 Apply all insulation, wrapping, vapour barrier, adhesives, coatings, and cement in strict accordance with manufacturer's recommendations.

.3 Do not apply any insulation or finishing when the ambient temperature in the space is less than 12°C.

3.2 **INSTALLATION APPLICATION**

.1 Apply all covering in a neat and workmanlike manner to present a clean appearance upon completion of the job.

.2 Apply all insulation in a manner to facilitate replacing and/or servicing of equipment.

.3 Make good and refinish cracks, undulations or any other deficiencies occurring in the insulation or vapour barrier.

.4 On all piping, equipment and ductwork, terminate the insulation neatly around all openings and items requiring periodic access. Insulate separately with removable 16 gauge galvanized sheet steel panels lined with rigid slab insulating materials providing equivalent insulation to that on the adjoining surface.

.5 Do not use staples on vapour barriers.

.6 Provide the following insulation work:

a) All combustion and fresh air intake ductwork - 50mm external 3 m from inlet and 25mm afterward.

b) All exhaust ductwork for a distance of 1.8m from exterior outlet - 25mm external.

c) All exterior supply / return air ducting 50mm external with weatherproofing.

d) All ductwork in unconditioned space – 25mm external.

e) All domestic hot and cold water piping (except domestic hot water piping within suite).

f) Storm pipe from roof hoppers and all above grade horizontal runs. Insulate roof hopper bottoms. Horizontal storm piping within U/G parking does not require insulation.

g) All condensate piping.

) All sanitary piping outside of heated area in U/G parking.

.7 On all piping having vapour barrier jacket, the adjoining section of insulation shall be butted firmly together and the longitudinal seams of the vapour jacket shall be sealed with vapour barrier adhesive. End joints shall be sealed with 100mm factory furnished vapour barrier strips.

.8 Apply insulation over clean dry surfaces butting and adjoining sections firmly together and pasting canvas smoothly over joints.

.9 Where the pipe hanger is around the insulation, provide a 150mm length at equal thickness of moulded thermo - 12 insulation, protected with an 18 gauge shoe, within the pipe saddle. Co-ordinate with Trades installing hangers referenced in Section 15050.

.10 Extend pipe and duct insulation and covering through sleeves, walls, floors, ceilings, and structural beams, unless indicated otherwise on drawings.

.11 Cover angles and standing seams which extend beyond face of applied insulation with 12mm thick blanket of glass fibre insulation fitted with factory applied facing of fire resistant kraft paper. Provide 75mm overlap on each side of angle or seam. Apply strips of 25mm thick

glass fibre insulation board over blanket type insulation, allowing extended portion of angle or seam to project through work.

.12 Seal holes, corners, and joints with 75mm wide scrim foil tape immediately following application of insulating materials.

.13 Refer to electrical drawings for piping to be electrically traced prior to installation of insulation.

.14 Fastenings on rectangular ducts:

a) Use 50% coverage of insulation adhesive. Flame spread 15, smoke development 0.

b) If duct is over 635 mm wide, provide weld pins in addition to insulation adhesive. Place weld pins at not more than 200 mm centres, and not less than two rows per side.

.15 Fastenings on round ducts: Use 100% coverage on insulation adhesive of flame spread 15, smoke development 0, and 100 mm wide self-adhesive tape rated under 25 for flame spread and under 50 for smoke development.

.16 Vapour barriers: Use quick setting adhesive for joints and lap sealing of vapour barriers. Flame spread 10, smoke development 0.

.17 Vapour barriers and insulation to be complete over the full length of duct or surface, without penetration for hangers, standing duct seams and without interruption at sleeves.

PART 1 - GENERAL

1.1 GENERAL PROVISIONS

.1 Conform to the General Provisions of Section 15010.

.2 Conform to acoustic report by HGC Engineering.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- Basic Materials & Methods Section 15050
- Liquid Heat Transfer Section 15700
- Air Distribution Section 15800

1.3 SUBMITTALS

.1 Submit shop drawings in accordance with Section 15010 paragraph 2.2 for all equipment items.

1.4 SCOPE OF WORK

.1 Supply all vibration isolation and sound control equipment as scheduled on the drawings and as outlined in the specifications.

.2 Isolation is not required for fire pumps, sewage and sump pumps, propeller fans or curb mounted roof fans.

.3 The mechanical sheet metal contractor shall provide to the vibration and sound control manufacturer all necessary data required for the proper selection of the vibration isolation and sound control equipment. The contractor shall also verify all final dimensions for bases, silencers and plenum.

.4 Silencers, isolators and restraining devices which are factory supplied with equipment shall meet the requirements of this Section.

.5 Include in this Division the supply of all concrete inertia pads (where required) or structural steel bases located between all vibrating equipment and the vibration isolation elements.

.6 Select isolators at the supplier's optimum recommended loading, and do not load beyond the limit specified in the manufacturer's literature.

.7 Provide hot dipped galvanized housings and neoprene coated springs for all spring isolators located out of doors or in areas where moisture may cause corrosion.

.8 Supply all of the noise control and vibration isolation equipment shall be by one approved supplier with the exception of those components which are factory installed and are standard equipment with the machinery.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATION TYPES.

.1 All isolators shall be of the following types, supplied by Vibron Ltd. or other acceptable manufacturers.

.2 Provide spring type isolation or spring isolated rails under cooling tower, pumps, all fans (except wall mounted or small cabinet fans), and other major equipment.

.3 Provide neoprene isolation on rod hangers at all horizontal air conditioning units.

2.2 **PIPING ISOLATION**

.1 All piping connected to evaporative coolers and pumps on spring type isolation shall be supported with type VH spring pipe hangers for at least the first three points of support. The hanger isolation supports shall have 1" static deflection.

.2 All piping supported from the mechanical floor or ceiling adjacent to critical areas shall be supported on type V spring isolators having 1" static deflection.

PART 3 - EXECUTION

3.1 **VIBRATION ISOLATORS**

.1 Execute the work in accordance with the specification and, where applicable, in accordance with the manufacturer's instructions and only by workmen experienced in this type of work.

.2 For all equipment mounted on vibration isolators, provide a minimum clearance of 2" to other structures, piping, equipment, etc.

.3 Co-ordinate with Section 15800 flexible connections for all ductwork connections to fans or plenums.

.4 For all electrical connections to isolated equipment, provide flexible conduit suspended in a semi-circular loop.

.5 The use of springs or neoprene as the piping isolation element shall be consistent with the method of isolation of the equipment to which the piping is connected - e.g., spring hangers on piping connected to equipment isolated on springs. The deflection shall be the same as specified for the equipment mounts.

PART 1 - GENERAL

1.1 Worked Included

.1 Furnish all labour, materials, tools, equipment all necessary for the complete installation of the Floating Concrete Floor System as shown on contract drawings, described on HGC Engineering's Acoustic Report and detailed herein.

1.2 Related Work Specified Elsewhere

.1 Works related to the installation of the Floating Concrete Floor System shall include but not be limited to the following:

Concrete and reinforcing
Waterproofing
Metal pipe and conduit sleeves
Floor drains

1.3 System Description

.1 The Floating Concrete Floor System shall consist of isolation, fiberglass perimeter isolation board, plywood concrete pouring formwork on top of the isolation pads, polyethylene waterproofing sheeting over the plywood formwork.

1.4 Quality Assurance

.1 Retain the services of a qualified professional engineer to design the floating floor system.

,2 Single source responsibility of the Floating Concrete Floor System is required to ensure continuity and quality. The supplier shall be responsible to furnish the design, supply the materials, and execute the installation. In addition, the supplier is to co-ordinate with other trades to ensure that their work has been conducted in accordance with the supplier=s recommendations when this work impacts the Floating Concrete Floor System.

PART 2 - PRODUCTS

1.1 Approved Supplier

.1 All products and materials for work as described in 1.3.1 shall be supplied and installed by Vibro-Acoustics or approved equal.

.2 Isolation Pads:

Isolation pads shall be nominal 2" thick. Isolation placement to be determined by supplier but not to exceed 24" centers.

The resonant frequency of the isolation pads shall not exceed 14Hz at the operating deflection.

The isolators shall be stable at the operating load and data to verify adequate performance of the isolators shall be provided to the Architect, if requested, before approval is given to proceed with manufacturing. The following will be requested:

Load-deflection curves for the isolator indicating the operating load range and the

maximum allowable load.

The measured dynamic stiffness of the isolators at the design load range.

The supplier shall submit shop drawings showing isolator placement to the Architect prior to commencing work.

.3 Formwork: The concrete pouring forms shall be 3/4" thick exterior grade plywood. The pouring form shall be assembled with metal unction plates during installation.

.4 Perimeter Board: Perimeter isolation shall be 1" thick rigid fiberglass board placed between the formwork panels and side walls or vertical surfaces.

.5 Perimeter Sealant: A one step polyurethane acoustical sealant as recommended by the floating concrete floor supplier to be supplied and installed by this section.

PART 3 - EXECUTION

.1 Installation

.1 The installation of all sound materials specified herein including those installed under the sections of the specifications shall be in accordance with procedures submitted by the supplier, and approved by the architect.

.2 After installation of the isolation materials and pouring form, the system shall be temporarily waterproofed by protecting the system with one layer of 6 mil polyethylene film overlapped and taped to all seams and connections to the building. After the concrete has been poured and allowed to cure, the perimeter and all penetrations shall be caulked using a one step polyurethane sealant.

.3 All sound isolation materials and building components supported by isolation material shall be free from rigid contact with any part of the building structure.

.2 Field Quality Control

.1 Prior to the start of work by this section inspects the substrate surfaces including but not limited to the waterproofing membrane. Report any conditions which may be considered detrimental to the performance of the Floating Concrete Floor System.

.2 After the concrete formwork has been installed by this section, inspect the installations conducted by other trades; including (but not limited to) floor drains, floor penetrations (conduits, piping, ductwork, etc) that they are installed in accordance with recommendations of the supplier of the Floating Concrete Floor System and report any deficiencies considered detrimental before the concrete has been poured.

.3 Supervise the pouring of the concrete to ensure that the formwork is not disturbed in any way that may be detrimental to the performance of the Floating Concrete Floor System.

.4 On completion submits a signed certificate that the Floating Concrete Floor System has been properly installed and shall reduce noise form mechanical equipment from being transmitted to the building.

PART 1 - GENERAL

1.1 GENERAL PROVISIONS.

.1 Conform to the General Provisions of Section 15010

.2 Provide work under this Section as shown or specified and in accordance with the requirements of the Contract documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE.

- Insulation Section 15180
- Basic Materials & Methods Section 15050

1.3 QUALITY ASSURANCE.

.1 Requirements of Regulator Agencies

a) Comply with local by-laws and standards.

b) Comply with regulations under Ontario Water Resources Act (including O. Reg.647).

c) Comply with regulations under the Power Corporation Act (including O. Reg. 168).

d) Comply with regulations under Building Code Act (including O. Reg. 925).

1.4 SUBMITTAL.

.1 Submit shop drawings in accordance with paragraph 2.2 Section 15010 for the following equipment items:

Plumbing Specialties
Plumbing Fixtures

.2 Submit inspection certificates obtained from local inspection authorities.

.3 Submit certificates indicating that all required testing has been completed.

1.5 DOMESTIC COLD WATER BOOSTER SYSTEM

.1 Quality Assurances

Single-Source Responsibility: Pumps shall be manufactured by the domestic water booster system manufacturer.

.2 Design Criteria

The drawings indicate sizes, profiles, connections and dimensional requirements of plumbing pumps and are based on the specific manufacturer types and models indicated. Pumps having equal performance characteristics by other manufacturers may be considered, provided that deviations in dimensions and profiles do not change the design intent and performance as judged by the engineer. The burden of proof for equality is on the proposes.

.3 Delivery and Storage

Store pumps in a dry location. Retain shipping flange protective covers and protective coatings during storage. Protect bearings and couplings against damage from sand, grit and other foreign matter. Comply with manufacturers= rigging instructions for handling.

PART 2 - PRODUCTS.

2.1 PLUMBING SPECIALTIES.

.1 Cleanouts

a) All cleanouts shall be made with standard TY branch or Y branch and bend using Watts Model CO-200-R cleanouts. Cleanout in finishing walls shall be concealed with Zurn square, secured nickel bronze access covers with frames. Size of frame to suit cleanout and block module.

b) In floor with tile finish use Watts CO-200-RT or RTS or Zurn inlay type cleanout with round or square recessed polished nickel alloy access cover and frame.

c) In all traffic areas cleanouts shall be epoxy coated cast iron body and heavy duty epoxy coated access cover. Watts C-200-RX.

d) In floors with waterproof membrane, use Watts CO-100-R-C or Zurn floor level cleanout with anchoring flange and membrane clamp.

e) Cleanouts shall be placed where shown, but whether shown or not, there shall be a cleanout at the base of every soil stack. Install cleanout on main building drain just before it leaves the building.

.2 Floor Drains (FD)

Jay R. Smith #2005-A05NB-P050 or approved equal floor drain, adjustable strainer, all duco coated, 9" (220mm) dia. cast iron body, reversible flashing clamp with seepage openings, no-hub outlet round strainer, 5" (127mm) nickel bronze, trap primer connection 1/2" (13mm). Mission #HW Series 'Heavy Weight' Couplings, MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.3 Floating Floor Drain (FD-1)

Jay R. Smith #9347-CAN-A05NB-P050-NB or approved equal floor drain, adjustable strainer, duco coated cast iron top and lower body, flashing clamps with seepage openings, neoprene isolation vibration gasket round strainer, 5" (127mm) nickel bronze, trap primer connection 1/2" (13mm), nickel bronze top. Mission #HW Series 'Heavy Weight' Couplings, MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.4 Gutter Drain

Jay R. Smith #1610T-U or approved equal gutter drain, all duco coated 6" (152mm) dia. body, bronze flashing clamp, threaded outlet , top secured with vandal proof screws, bronze top. Mission #HW Series 'Heavy Weight' Couplings, MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.5 Hub Drains (HD)

Hub Drains shall be Watts FD-100-DDC or Zurn in 75mm outlet size. Drain shall be complete adjustable nickel bronze hub with flange and clamp device.

.6 Roof Drains

Roof drain (RD) for tower & greenroof shall be standard flow, Jay R. Smith #1010-R-C-E-CID or approved equal roof drain, all Duco coated cast iron body, flashing clamp with seepage openings, sump receiver, underdeck clamp, extension solid (height to suit roof construction), cast iron dome. Mission #HW series 'Heavy Weight' couplings, MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.7 Area Drain

Parking area drain (AD) shall be Watts FD-460-AF-5-6 Watts or approved equal with extra heavy duty hinged cast iron grate, Epoxy coated steel basin and trapped outlet with cleanout. Stairwell area drains shall be Watts FD-330-1-5-9. All epoxy coated cast iron body complete with seepage flange, clamping device, and secured square (200mm x 200mm) (8" x 8") light duty bronze pedestrian grate. Provide aluminum sediment bucket within area drain. Grate to be hinged. Provide a 4" (100mm) connection located on the bottom of the drain.

.8 Catch Basin

Jay R. Smith #9864 or approved equal catch basin, precast polymer concrete with ductile iron frame. Preformed knockedout panels are provided on each side of the catch basin for connection to channels, ductile iron grate. Mission #HW Series 'Heavy Weight' Couplings, MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.9 Scupper Drain (SD)

Jay R. Smith #1530 or approved equal scupper drain angle grate, all duco coated cast iron body, flashing clamp, 45 degree outlet, cast iron loose set angle grate. Mission #HW Series 'Heavy Weight' Couplings**,** MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps. Provide back water valve for elevator pit scupper drains Model 7000S06 (SD-1).

.10 Bi-Level Area Drain (BLD)

Driveway Area - Watts #FD-460 -NH-15-5-AF-4 Area Drain**,** epoxy coated cast iron body with anchor flange, weepholes, 12-3/4" x 12-3/4" (324mm x 324mm) adjustable top tractor grate, no hub , adjustable extension (4" to 5-5/8"), sediment bucket, ductile iron grate.

Landscape Area - Watts #RD-200-CP -NH-85-B-D-4 Small Area Promenade Top Roof Drain, epoxy cast iron body, flashing clamp with integral gravel stop, 8" x 8" (203mm x 203mm) square top, no hub , heel proof epoxy coated ductile iron promenade top, perforate extension, sump receiver, underdeck clamp.

.11 Stairwell Area Drain or Terrace Drain (RD-1)

Jay R. Smith #1470 4-R-C-E-NB or approved equal drain, all duco coated with 8-1/2" (16mm) body and 8" x 8" (203mm x 203mm) square secured nickel bronze grate, flashing clamp with seepage openings, 4" (102mm) Outlet , sump receiver, underdeck clamp, extension solid (height to suit roof construction), nickel bronze top. Mission #HW Series 'Heavy Weight' Couplings**,** MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.12 Landscape Drain (LD)

. Jay R. Smith #2675-CID Planter Drain, all duco coated 12" (300mm) diameter cast iron body, flashing clamp with seepage openings, large S.S. mesh covered , cast iron dome.Mission #HW Series 'Heavy Weight' Couplings, MJ couplings, constructed of extra wide 4 to 6 band corrugated type 304 stainless steel bands, with heavy duty worm drive clamps.

.13 Trench Drain

Trench Systems – Precast Polymer Concrete with Integral Rail – Heavy Duty Class C: For Commercial Pneumatic Tire Traffic Patterns, Forklifts and Tractor Trailers (Load of 260 PSI (37440 Pounds per Square Foot)
Jay R. Smith #9818-9870-465-SSP or approved equal Trench Drain, precast polymer concrete 5.1" (130mm) wide sloped modular system with interlocking components, integral channel rail frame, length to suit, built-in slope of 0.6% with radiused bottom 1/4" Dia. Perforated Stainless Steel Grate Open Area/1 Meter(27.60 SQ.IN.).

.14 Fixture Carriers

a) Wall-hung Urinals shall be supported independently of the wall by Watts Series CA-321 or Zurn Urinal carrier with two supporting plates, heavy duty rectangular tubular steel uprights and integral welded foot support. Refer to Watts Fixture - Carrier Selector Index for Carrier designed for specific Fixture manufacturer. CA-321 is recommended for most applications.

b) Wall-hung Lavatories shall be supported independently of the wall by Watts Lavatory Chair Carriers. Carriers shall have heavy duty rectangular tubular steel uprights and integral welded foot support. Wherever possible fixtures shall be supplied with punching for concealed arms and Watts CA-411 or Zurn shall be supplied. Supply Chrome plated escutcheons on slab type lavatories. Where fixtures are not available with punchings for concealing arms, lavatories shall be Watts CA-421 plate type.

.15 Trap Seal Primer

SMS INC. #PR-500 SMS INC./P.P.P. #PR-500 or approved equal Automatic Trap Seal Primer Valve, cast brass body, serving individual or remote area drains (primer automatically activated when there is a pressure drop in the system) with 1/2" (12.7mm) NPT (MtoF) connections with strainer and integral back flow preventer & vacuum breaker. (For 2, 3 or 4 drains provide primer unit with distribution unit assembly #DU-U).

.16 Non-Freeze Wall Hydrants

Jay R. Smith #5619QT or approved equal Box Type Wall Hydrant, 1/4 turn non-drip, ceramic cartridge, 3/4" (19mm) non freeze wall type with bronze nickel face and stainless steel with full 180 deg. cover opening box, self-draining integral vacuum breaker. Operating keys, stainless Steel Face.

.17 Shock Absorber

Shock absorbers shall be Watts Series SG shock Guard or approved equal, all stainless steel construction with nesting bellows precharged with air.

.18 Pressure Reducing Valves

a) Design valve in accordance with the following:

i. Full internal port, ductile iron body, 150 lb flanged ends and stainless steel internal trim. Stainless steel internal trim comprised of the following:

- Machined stainless steel cover bushing.
- Machined stainless steel dura-clean one-piece stem.
- Machined stainless steel disc guide.
- Machined one-piece stainless steel seat including stem bushing.

ii. Main valve not to include any locating pins, snap rings or stem o-rings.

iii. No pistons or rolling diaphragms permitted – all main valves to use a flat diaphragm system.

iv. Valve body and cover to include 360˚ mating machined surfaces to ensure valve stem and cover bushings align concentrically.

v. NSF 61 certified fusion bond epoxy coating on interior and exterior surfaces.

vi. Valve manufacturer to supply a complete line of main valves, from 37 mm to 1200 mm diameter, with the same internal component design throughout.

vii. Includes pilot line strainer and adjustable opening speed control.

viii. Adjustable pressure reducing pilot range 2 – 30, 15 – 75, 20 – 105, or 30 - 300 psi.

ix. Valve manufacturer to provide a cavitation analysis report for each valve under the expected flow and pressure conditions.

b) Valve to provide pressure reducing functionality.

c) Valve to be Cla-Val model 90G-01ASKC or approved equal.

d) Acceptable Manufacturer: Cla-Val or approved equal.

.19 Water Filtration System

4" Judo model # JPF-A/TP-4 - Profirmat back-wash filters or approved equal shall be installed inside meter room to remove all coarse and fine-grained impurities. The standard size of the filter sieve is 0.1mm. The sieve is made of silver-plated, high grade stainless steel.

.20 Domestic Hot Water Tempering Valve

Low Zone: Leonard ECO-MIX™ Model **TM-2020B-2PS-LF** or approved equal, 3” inlets, 3” outlet, 2.0 GPM minimum, 452.0 maximum flow capacity.
156 GPM flow capacity @ 5 PSI system pressure drop.
High Zone: Leonard ECO-MIX™ Model **TM-1520A-2P-LF** or approved equal, 2” inlets, 2” outlet, 2.0 GPM minimum, 330.0 maximum flow capacity.
96 GPM flow capacity @ 5 PSI system pressure drop.

Provide factory assembled and tested large TYPE TM thermostatic water mixing valve, small TYPE TM valve, DURA-trol® solid bi-metal thermostat (directly linked to valve porting to control the intake of hot and cold water and compensate for supply temperature or pressure fluctuations) with Seven Year Limited Warranty, color coded dials (HOT-

COLD with directional indicators), locking temperature regulator handles, adjustable limit stops set for 120°F (49°C), integral hot and cold supply checkstops Outlet ball valve shutoffs and optional color coded dial thermometer, inlet piping manifold Factory preassembled and tested, rough bronze finish. System will be mounted on galvanized strut. System shall provide full time standby service should one mixing valve require maintenance and shall be piped according to Leonard's required piping method. Valve assemblies are ASSE Standard 1017 listed and 3rd Party certified as Lead Free.

.21 Double Check Valve

Watts - Backflow Preventer, Double Check Valve Assembly (DCVA) model number 757-NRS, 4" 304 (Schedule 40) stainless steel body, non-rising stem resilient seated gate valves, shall be installed for non-health hazard pollutants that are objectionable but not toxic, from entering the potable water supply system. Compact design, 70% lighter than traditional designs. The housing shall be constructed of 304 Schedule 40 stainless steel pipe with groove end connections of two independent tri-link check modules within a single housing, sleeve access port, four test cocks and two drip tight shutoff valves. Tri-link checks shall be removable and serviceable, without the use of special tools. Bi-link checks shall have reversible elastomer discs and in operation shall produce drip tight closure against reverse flow caused by backpressure or backsiphonage. Temperatures Range: 33°F - 110°F (0.5°C - 43°C) continuous, 140°F (60°C) intermittent. Maximum Working Pressure: 175 psi (12.1 bar). The assembly shall meet requirements of ASSE 1015, CSA B664.5, FM, UL classified. Check with local authority having jurisdiction regarding degree of hazard present, vertical orientation, frequency of testing or other installation requirements.

2.2 **PLUMBING FIXTURES.**

.1 Plumbing fixtures list to be supplied by Deltera.

2.3 **DOMESTIC COLD WATER BOOSTER SYSTEM.**

.1 Design Envelope Domestic Water Booster System

Provide an Armstrong Design Envelope Packaged Booster System envelope number 6825. The design envelope shall encompass an initial design point of 270.0 USgpm at 167.0 ft head.
The design envelope shall also be capable of supplying 16.9 L/s at 62.7 m head at 67 % minimum efficiency level.

.2 Pumps

Each Vertical MultiStage (VMS) pump, with pump characteristics which provide rising heads to shut off, shall be supplied with a 10 hp, ODP, 575v/3/60 , NEMA Premium® efficiency motor and an Armstrong UL Type-12 enclosure variable speed drive, which shall be integrated with the motor. Drives shall not be enclosed within the control panel.

Variable speed drives supplied shall have the following features: VVC-PWM type providing near unity displacement power factor without the need for external power factor correction capacitors at all loads and speeds, DC link chokes for the reduction of mains borne harmonic currents, UL and C-UL Listed & CE Marked showing compliance with both the EMC Directive 89/336/EEC and the Low Voltage Directive 72/23/EEC, RFI filters incorporated within the drive to ensure it meets the emission and immunity requirements of EN61800-3 to the 1st Environment Class C1 (EN55011 unrestricted sales class B), drive and motor protection shall include: motor phase to phase fault, motor phase to earth fault, loss of supply phase, over voltage, under voltage, motor over temperature, inverter overload, over current.

.3 Pump Construction

Pump Casing - Cast Iron with ANSI-150 flanges.
Impeller - Stainless Steel, fully enclosed type.
Shaft - Stainless Steel pump shaft.
Coupling - Rigid spacer type of Brass or Steel. Coupling to be designed to allow removal of all mechanical seal components for servicing without removal of the pump.
Mechanical Seals - Mechanical shaft seal with FPM® secondary seal, carbon rotating face and silicon carbide stationary seat.

.4 Pump Sequencing

The pump designated as the lead pump shall start following a 5 second On-Delay time after sensing a drop in the system pressure 5 PSI below the desired set point value. The pump controller shall compare a signal from the discharge pressure transducer to the set point value and the lead pump speed shall ramp up in order to satisfy the set point pressure. The lag pump shall start following a 60 second On-Delay time, when the lead pump exceeds its best operating point (BOP), and a minimum run timer shall ensure that the lag pump runs for a minimum of 60 seconds. The lag pump shall ramp down in speed and turn off when the pumps that are running are operating at a point below the BOP and the lag pump minimum run timer has expired. The lead pump shall continue to operate and meet system requirements based on the set point value. The lead pump shall alternate every 24 hrs of operation where the second pump shall start and run for a period of 5 seconds, both pumps shall operate, the first pump on shall ramp down and the new lead pump shall continue to operate as above to meet system requirements.

.5 Lead Pump Shutdown Controls

All systems are equipped with a "No-Flow" shutdown that will stop the pumps when the pump controller determines there has been a "No-Flow" condition for a continuous 5-minute period. The lead pump will start again once a drop in pressure of at least 5 PSI is measured on the discharge of the system. The system can be manually operated by means of the virtual Hand-off-Auto (HOA) selector buttons provided on the operator interface.

.6 Control Panel

The control panel shall be of the programmable logic controller (PLC) type. The complete control panel assembly and all internal devices shall be UL508 and/or CSA labeled. The panel shall be complete with NEMA Type 12 Painted Steel Enclosure (STD) and include door interlocked main disconnect, water tight LCD interface, fused drive connections, adjustable time delays, Hand-Off-Auto selector for each pump and minimum run timers. The control circuit shall include fault relay circuit to turn on the next pump should the lead pump fail.

The controller must be capable of controlling up to 2 pumps, with a 4-20 mA analogue signal using pressure as the control variable. Controller design shall include provisions for low flow energy savings, soft fill mode, pressure setback mode, emergency power mode, best-operating-point (BOP) sequencing, end of pump curve protection, 24hr operation automatic alternation of pumps, built-in pump on-delay and minimum run timers, re-settable pump elapsed run time meters, smooth pump starting and sequencing, on-screen field modifiable control and alarm parameters, option for alphanumeric or color graphic touchscreen display, high suction pressure shutdown and no-flow shutdown with drawdown tank/system optimization.

On-screen alarm display with alarm identification shall be incorporated with the following alarms included: low and high system pressure shutdown, low suction pressure or level shutdown, pump failure drive fault, and suction and discharge pressure sensor failures.

The controller shall include on-screen fault description and possible cause information with alarm horn for alarms.

Non-volatile factory set parameters must be capable of being restored at any time in the field without requiring any programming device or connection to an external source. The controller must hold software in FLASH memory storage which prevents accidental loss of data due to voltage surge or spike.

All controls to be factory pre-wired and tested in accordance with provisions of the national electrical code. All control wires shall be individually numbered and each component shall be labeled accordingly. All internal wiring shall be Copper stranded, A.W.G. with a minimum 90°F rating. The controller shall bear the UL508 label for industrial controls.

Variable Speed Control Option Low Level Cut Off Included
Serial Communications Port complete with Siemens FLN protocol.

.7 Instrumentation and Controls

Pump system shall be supplied with header mounted liquid filled pressure gauges for indicating suction and discharge pressure.

.8 Factory Prefabriction

The system shall be factory prefabricated with a stainless steel base and panel support, including lug butterfly isolation valves on the suction and discharge of each pump, flanged spring loaded check valves on the discharge as well as 102 mm Stainless Steel headers with Threaded system connections and Stainless Steel base and panel support. All interconnecting piping shall be stainless steel. The only field connections required shall be piping to the system headers and one incoming power connection at the control panel. The maximum working pressure of the package shall be 140.9 m.

.9 Factory Test and Certification

The booster system and its component parts shall undergo a complete operational flow test from zero to 100% design flow rate under the specified suction pressure conditions. The system certification shall include copies of the test data as certified by a factory engineer. Performance test certifications and extra copies should be placed inside the control panel with an installation manual. In addition, the entire system shall be third party certified by Underwriters Laboratories Inc. in accordance with OSHA 29 CFR with references to nationally recognized testing laboratories.

.10 Manufacturers

The above specification describes equipment manufactured by Armstrong, ITT or approved equal. Alternate manufacturers of equipment will be considered provided that they are completed equal as to type, capacity and efficiency of pumps and controls. Alternate manufacturers' submittals must be certified by an officer of the company who is proposing that their system complies with the specifications in every detail.

2.4 **SUMP PUMPS**

.1 Supply and install, as shown on the drawings, sump and/or sewage pumps, equal to BARNES PUMP, having capacities as shown. Pumps shall be vertical heavy duty type with submersible motor and complete with 20 ft power cord, Duplex alternator, starter and dead end control panel, level sensors/alarm, curb frame manhole and cover plate length to suit.

.2 Provide suitable steel angle frame with trim bar and bolted steel coverplate with handhole. Sewage pump coverplate and handhole shall be gasketted.

2.5 SPLIT-COUPLED VERTICAL INLINE PUMPS

.1 Supply and install as shown on plans and specifications, Armstrong Series 4300 IVS pumps. The pumps shall be single stage, single or double suction type, vertical inline design with integrated controls. The seal shall be serviceable without disturbing the motor or the piping connections. The capacities and characteristics shall be as outlined in the plans and specifications.

.2 Pump casing shall be constructed of ASTM A48 class 30 cast iron with ANSI 125 / PN16 flanges for working pressure below 175 psig (12 bar) at 150°F (66°C) and ASTM A536 ductile iron with ANSI 250 / PN25 flanges for working pressures to 375 psig (25 bar) at 150°F (66°C). The casing shall be hydrostatically tested to 150% maximum working pressure. The casing shall be radially split to allow removal of the rotating element without disturbing the pipe connections. The pump casing shall be drilled and tapped for gauge ports on both the suction and discharge connections and for a drain port at the bottom of the casing. The casing shall have an additional tapping on the discharge connection to allow for the installation of a seal flush line.

.3 The pump shall have a factory installed vent/flush line to insure removal of trapped air from the casing and mechanical seal cooling. The vent/flush line shall run from the seal chamber to the pump discharge.

.4 The impeller shall be bronze, fully enclosed type. The impeller shall be dynamically balanced to ANSI Grade G6.3 and shall be fitted to the shaft with a key. Two-plane balancing is required where installed impeller diameter is less than 6 times the impeller width.

.5 The pump shaft shall be stainless steel.

.6 The coupling is to be rigid spacer type constructed of high tensile aluminum alloy. The coupling is to be designed to be easily removed on site to reveal a space between the pump and motor shafts sufficient to remove all mechanical seal components for servicing and to be replaced without disturbing the pump or motor.

.7 The pump shall be fitted with an outside balanced type mechanical seal, with Viton elastomers and antimony carbon (or resin-bonded carbon for potable water applications) vs. silicon carbide faces rated up to 250°F (121°C). A 316 stainless steel gland plate shall be provided with a factory installed flush line with manual vent.

.8 All split coupled pumps shall be provided with a lower seal chamber throttle bushing to ensure seals maintain positively cooling and lubrication.

.9 If required to improve seal chamber cleanliness, supply in the flush line to the mechanical seal a 50 micron cartridge filter and sight flow indicator, to suit the working pressure encountered.

.10 Alternately, supply in the flush line to the mechanical seal a maintenance-free sediment separator, with sight flow indicator for pump differential pressures exceeding 30 psig (or 200 kPa).

.11 The motor frame shall be NEMA TC type. Motor enclosure is to be ODP or TEFC with NEMA Premium Efficiency 12.12 rating. Acceptable motor insulation for variable speed operation is NEMA MG-1 Part 31.

.12 The variable frequency drive & controls shall be rated UL Type 12 or UL Type 4X and be an integral component of the pumping unit.

.13 The integrated VFD shall be of the VVC-PWM type providing near unity displacement power factor (cos Ø) without the need for external power factor correction capacitors at all loads and speeds. The VFD shall incorporate DC link chokes for the reduction of mains borne harmonic currents and to reduce the DC link ripple current thereby increasing the DC link capacitors lifetime. RFI filters will be fitted as standard to ensure the VFD meets low emission and immunity requirements.

.14 VFD and motor protection shall include: motor phase to phase fault, motor phase to ground fault, loss of supply phase, over-voltage, under-voltage, motor over-temperature, inverter overload, over-current.

.15 VFD shall have Sensorless control software to provide automatic speed control in variable volume systems without the need for pump mounted (internal/external) or remotely mounted differential pressure sensor. The default operating mode under Sensorless control shall be Quadratic Pressure Control (QPC) whereby head reduction with reducing flow will be according to a quadratic control curve, the head at minimum flow being 40% of the design duty head. Control mode setting and minimum/maximum head setpoints shall be user adjustable via a built-in programming interface.

.16 The VFD shall have the following additional features:
> Sensorless override for BAS/BMS control signal
> Manual pumps control or closed loop PID control
> Programmable skip frequencies and adjustable switching frequency for noise and vibration control
> Auto alarm reset
> Four programmable digital inputs, two analog inputs, one programmable analog / digital output
> One volt-free contact
> One RS485 port for serial communications to building management systems
> Standard serial communication protocols Siemens FLN

Environmental Ratings
> Temperature: 14°F to 113°F up to 3300 ft (-10°C to 45°C up to 1000 m)
> Max Relative Humidity: 0 to 95%

PART 3 - EXECUTION.

3.1 PLUMBING SPECIALTIES.

.1 Cleanouts

a) Cleanouts shall be the same size as pipe up to 100mm and not less than 100mm for larger pipes.

b) Provide cleanouts at the end of mains and branches, at changes in directions, in long straight runs, at the base of all soil stacks and rainwater leaders and where required by code.

c) Use extended cleanouts for piping installed below grade and in furred ceiling spaces.

.2 Floor and Pit Drains

a) Reference shall be made to the Architectural Drawings for slopes of floors and locations of floor drains with regard to furniture, benches, etc. and any specific placing.

b) Provide drains, complete with traps where shown on drawings.

c) Provide trap seal primers and supply lines to each drain.

.3 Area and Hub Drains.

a) Provide area and hub drains where indicated on drawings.

b) Connect drains to storm system as indicated.

.4 Roof Drains

a) The Mechanical Contractor shall locate the position of roof hoppers and hand over to the General Contractor or his roofing sub-contractor the hopper for installation. Application of roofing and mopping-in and making water tight by roofing sub-contractor.

b) Responsibility for making the hopper water tight shall rest with the General Contractor and his Roofing sub-contractor.

c) Underdeck clamps to hopper base must be installed at all hoppers by the Mechanical Contractor.

.5 Water Hammer Arrestors

a) Provide 600mm air chambers fabricated from Type M, copper tubing, with capped end, or water hammer arrestors, at each plumbing fixture or fixture group, and wherever else necessary to prevent water hammer.

3.2 **PLUMBING FIXTURES.**

.1 For precise location and mounting heights of the fixtures and trim, refer to the Architectural Drawings.

.2 Co-ordinate the work of this Division with that of other Divisions with regard to all openings in wall and floors for any fully or semi-recessed fixtures.

.3 Conform to detailed Architectural and Electrical Drawings countertop installation with regard to sink size and location in countertop to ensure clearance with counter structural.

.4 Fixtures shall be carefully stored until ready for placing. After placing, they will be protected from danger by pasting on paper or other methods. When job is ready for service all fixtures and fittings will be properly cleaned. Any scraped chipped or permanently stained fixtures shall be replaced by the Contractor.

.5 All fixtures are to be white unless otherwise noted.

.6 All manufacturer's labels to be left on fixtures until after Final Inspection and then removed.

.7 Each fixture shall have compression type shut-off valves at the fixture in addition to the faucets on each fixture. These valves will be adjusted to prevent excessive flow.

.8 Where fixture connections pass into walls, floors or ceilings, they shall be fitted with proper escutcheons.

.9 All visible parts of trim of the fixtures including faucets, escutcheons wastes, strainers, traps, supplies stops etc., shall be chrome plate

.10 When installing chrome plated trim and accessories, proper care shall be taken. Any wrench or other tool marks on the plating will be sufficient cause for rejection.

.11 All exposed pipe and fittings and fixtures shall be rigidly supported. All fastenings to walls and partitions shall be firmly made without damage to wall finish.

.12 Connect all services to plumbing fixtures.

.13 Install all plumbing fixtures supplied by others and connect all services to plumbing fixtures.

3.3 **DOMESTIC COLD WATER BOOSTER SYSTEM.**

.1 The above specification describes equipment manufactured by S.A. Armstrong Ltd., Toronto, ON, Canada. Alternate manufacturers of equipment will be considered provided that they are completely equal as to type, capacity, and efficiency of pumps and controls. Alternate manufacturer's submittals must certify by an officer of the company who is proposing that their system complies with the specifications in every detail.

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS.

.1 Conform to the General Provisions of Section 15010.

.2 Provide work under this Section as shown or specified and in accordance with the requirements of the Contract documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- Basic Materials & Methods	Section 15050
- Insulation	Section 15180
- Liquid Heat Transfer	Section 15700
- Electrical Work	Division 16

1.3 QUALITY OF ASSURANCE.

.1 Conform to regulations of CSA Standards current edition, Installation for Gas Burning Equipment, and Ontario Regulation 212/01 under the Technical Standards and Safety Act.

1.4 SUBMITTALS.

.1 Submit shop drawings in accordance with Section 15010 paragraph 2.2 for all equipment items.

1.5 AIR HANDLING UNIT

.1 Quality Assurances

- Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum of five years documented experience.
- Units shall be manufactured in a facility registered to ISO 9001:2000 manufacturing quality standard.
- Air-handling unit assembly shall have UL 1995 certification for safety.
- Products requiring electric connection shall be listed and classified by ETL and CSA as suitable for the purpose specified and indicated.
- Coil performance shall be certified in accordance with ARI Standard 410.
- Air-handling unit shall be ARI 430 listed and meet NFPA 90A requirements.

.2 Deliveries, Storage and Protection

- All indoor units, painted or unpainted, shall be completely shrink-wrapped from the factory for protection during shipment. Tarping of bare units is unacceptable.
- Inspect for transportation damage and store in clean dry place and protect from weather and construction traffic. Handle carefully to avoid damage to components, enclosures and finish.

.3 Start-up Requirements

- Do not operate units until ductwork is clean, filters are in place, bearings lubricated, condensate properly trapped, piping connections verified and leak tested, belts aligned and tensioned, all shipping braces have been removed, and fan has been test run under observation.

PART 2 - PRODUCTS.

2.1 **Air Handling Unit**

.1 General

a) Supply indoor air handling units and components as shown, scheduled, and indicated on the Drawings.

b) The requirements of the General Conditions, Supplementary Conditions, Division 1, and Drawings apply to all work herein.

c) The design shown on the drawing is based upon products of the manufacturer scheduled. Alternate equipment manufacturers, as listed, will be acceptable if equipment meets the scheduled performance and complies with these specifications. The intent of this specification requirement is to assure that the products are delivered through a quality system and framework that will assure consistent quality. If equipment manufactured by manufacturer other than that scheduled is utilized, then the Mechanical Contractor shall be responsible for coordinating and any additional costs with the General Contractor and all affected Subcontractors to ensure proper provisions for installation of the furnished unit. This coordination shall include, but not be limited to, the following:

a. Structural supports for units.
b. Piping size and connection/header locations.
c. Electrical power requirements and wire/conduit and over current protection sizes.
d. The Mechanical Contractor shall be responsible for all costs incurred by the General Contractor, Subcontractors, and Consultants to modify the building provisions to accept the furnished units.

d) - AMCA 99 : Standard Handbook

- AMCA 210 : Laboratory Methods of Testing Fans for Rating Purposes

- AMCA 300 : Test Code for Sound Rating Air Moving Devices

- AMCA 301 : Method of Publishing Sound Ratings for Air Moving Devices

- AMCA 500 : Test Methods for Louvers, Dampers, and Shutters

- ANSI/AFBMA 9 : Load Ratings and Fatigue Life for Ball Bearings

- ANSI/UL 900 : Test Performance of Air Filter Units

- ARI 410 : Forced-Circulation Air Cooling and Air Heating Coils

- ARI 430 : Standard for Application of Central-Station Air Handling Units

- ARI 260 - Sound Rating of Ducted Air Moving and Conditioning Equipment

- NFPA 90A : Installation of Air Conditioning and Ventilation Systems

- SMACNA : Low Pressure Duct Construction Standards

- AMCA 611-95 : Methods of Testing Airflow Measurement Stations for Rating

- ASHRAE 52.1/52.2 : Method of Testing General Ventilation Air Cleaning Devices for Removal Efficiency by Particle Size
- ASHRAE 62 : Ventilation for Acceptable Indoor Air Quality
- ASHRAE 90.1 : Energy Standard for Buildings Except Low-Rise Residential Buildings
- ARI 1060- Standard for Rating of Air-Air Energy Recovery Ventilating Equipment

e)
- Submit shop drawings and product data as detailed
- Shop drawings shall indicate assembly, unit dimensions, weight loading, required clearances.
- Construction details and field connection details.
- Product data shall indicate dimensions, weights, capacities, ratings, fan performance, motor electrical characteristics, gages, and finishes of materials.
- Provide fan curves with specified operating point clearly plotted.
- Submit product data of filter media, filter performance data, filter assembly, and filter frames.
- Submit electrical requirements for power supply wiring including wiring diagrams for interlock and control wiring, clearly indicating factory-installed and field-installed wiring.
- Submit manufacturer's installation instructions as detailed

f)
- Submit operation and maintenance data as detailed.
- Include instructions for lubrication, filter replacement, motor and drive replacement, spare parts lists, and wiring diagrams.

g)
- Conform to AMCA 210 for fan performance ratings.
- Conform to E.T.L. or U.L. standards.
- Conform to ARI 410 for capacities, pressure drops, and selection procedures of air coils.
- Conform to ARI 430 for all fabrication procedures of air handling units.
- Utilize only ANSI/UL 900 listed Class I or Class II filter media, approved by local authorities.
- Utilize only ISO9001, 9000, or 9002 certified facilities in the manufacturing of the air-handling unit.
- Electric control wiring shall be in accordance NEC codes & ETL requirements.
- Motors shall satisfy the federally mandated Energy Policy Act (EPACT).

- Test Airflow Monitoring Stations in accordance with AMCA 611-95.

- Provide Certified Ratings Seal for Airflow Measurement Performance.

h) - All handling and storage procedures shall be per manufacturer's recommendations.

- Unpainted units shall be shrink-wrapped by the manufacturer prior to shipment to prevent damage due to weather and road debris during transportation and thereafter while in storage awaiting installation. Alternatively, units may be completely covered by tarps while in transit or shipped in an enclosed truck. Units not factory shrink-wrapped shall be re-covered by the contractor at the job- site while awaiting installation. Protection of the complete unit for avoidance of general rusting must be handled as best suits the circumstances. Store in a place protected from construction traffic and handle carefully to avoid damage to components, enclosures, and finish.

- All openings shall be protected against damage from shipping.

- Safety warning labels shall be clearly marked in 3-language format.

- Filters will ship loose from factory with unit as scheduled.

- All loose-shipped items need to be packed, protected and secured with the air units.

- Motors should be protected and inspected in accordance with the manufacturer's specific instructions regarding periods of long storage.

i) - The manufacturer's standard warranty shall be 18 months parts and 12 months labor, from the date of factory shipment. The warranty shall not include parts associated with routine maintenance, such as belts, air filters, etc.

j) - Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.

- Manufacturer's start-up requirements must be complied-with to ensure safe and correct operation.

.2 Acceptable manufacturers to be Johnson Controls/York, Carrier, Trane, Haakon, Ventrol. Basis of design is Johnson Controls/York

.3 General Descriptions

a) AHU-1 is built up systems consisting of separate supply fan/coil section, motorized face and bypass damper, inlet motorized damper and intake filter section.

b) Fabricate air-handling units suitable for the scheduled capacities.

c) Factory test and balance fan design and drives to limit vibration (displacement in mils) at operating speeds.

d) Base performance on altitude.

e) All internal components specified in the air handling unit schedule shall be factory furnished and installed. Unit(s) shall be completely factory assembled.

f) Units will ship in sections for contractor reassembly. AHU-1, 2 will require field fabricated and installed duct transitions between major components.

.4 Unit Casing

a) Construction

- Unit shall be constructed of a complete frame with easily removable panels. Removal of any panel shall not affect the structural integrity of the unit. Single height coil sections shall have removable frame sections to facilitate vertical coil extraction.

- All units shall be supplied with 16-gage, G-90 galvanized steel base rails. Bolt-on legs are NOT acceptable. Perimeter 10-gage lifting lugs for overhead lifting shall be provided on each section. Slinging units in place of lifting lugs shall not be acceptable.

- Unit shall be thermally broken to minimize the conduction path from the inside of the casing to the outside.

- Casing panels (top, sides and bottom) shall be constructed of galvanized steel, and shall have one of the following exterior finishes as specified:

  o Pre-painted with a baked enamel finish passing 500-hour salt spray test (ASTM B-117) for pre-painted steel and 125-hour.

  o Marine level 1 procession test (ASTM G-85) for pre-painted steel. Unpainted G-90 galvanized steel.

- Casing panels (top, sides and bottom) shall be constructed of galvanized steel, and shall have one of the following interior finishes as specified:

  o Pre-coated with a silver zeolite antimicrobial material registered by the US EPA for use in HVAC applications.

  o Unpainted G-90 galvanized steel.

- Casing panels (top, sides and bottom) shall have no exterior exposed raw edges that could lead to rust formation. All casing corners shall be radiused or chamfered.

- Casing panels (top, sides and bottom) shall be solid double-wall construction with insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13.

- Casing deflection shall not exceed a 1:200 ratio when subject to an internal pressure of ∀ 5-in. wg.

- Side panels shall be easily removable for access to unit and shall seal against a full perimeter automotive style gasket to ensure a tight seal.

- The panel retention system shall comply with UL 1995 which states all moving parts (for example, fan blades, blower wheels, pulleys and belts) that, if accidentally contacted, could cause bodily injury, shall be guarded against accidental contact by an enclosure requiring tools for removal.

- Accessibility options shall be as follows:

  o Hinged double-wall access door on either side with removable access panel(s) on the other side.

- Depending on the options selected and the remaining available space inside each section, the following options may be available:

  o Thermal pane reinforced glass viewports shall be factory-installed on the access panel(s) or door(s) of the section.

  o Marine lights shall be factory installed with or without convenience outlets.

- Fan supports, structural members, panels, or flooring shall not be welded, unless aluminum, stainless steel, or other corrosion-resistant material is used. Painted welds on unit exterior steel or galvanized steel are not acceptable.

- All coil sections shall be solid double-wall construction with insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13. Single height coil sections shall have removable frame sections to facilitate vertical coil extraction.

- Blow-thru sections shall have a diffuser plate as an integral part of the fan section.

- Access doors shall be solid double-wall construction with insulation sealed between the inner and outer panels. Panel assemblies shall not carry an R-value of less than 13. Latches shall be non-removable and operated with a simple tool.

- Drain pans shall be insulated double-wall stainless steel construction. The pane shall be sloped in 3 directions toward the drain fitting. Drain pan shall have a recessed bottom drain design with 1-1/2 in. MPT connection exiting through the hand side or opposite side of the casing as specified. Drain connection shall be insulated from the drain pan to the point at which it exits the casing. One drain outlet shall be supplied for each cooling coil section. Drain pan shall allow no standing water and comply with ASHRAE Standard 62. Where 2 or more coils are stacked in a coil bank, intermediate drain pans shall be provided and the condensate shall be piped to the bottom drain pan. The bottom coil shall not serve as a drain path for the upper coil.

.5 Fans

a) General

- Supply air Plenum fan sections shall have one single-width single-inlet (SWSI) airfoil fan wheel. Airfoil blades shall be double thickness design constructed of heavy gage, high strength steel or aluminum continuously welded to the backplate and the spun inlet flange. Entire fan assembly shall be cleaned, primed and painted with alkyd enamel, except for an aluminum fan wheel when supplied. They shall be designed for continuous operation at the maximum rated fan speed and motor horsepower. Fans

shall have an AMCA class rating corresponding to the static pressure at which the fan is designed to operate as Class II. Completed fan assembly shall be dynamically balanced to minimum grade of G 6.3 per ANSI/AMCA 204-96 at design operating speed using contract drive and motor if ordered. Installing Contractor to provide duct openings in the plenum fan section. Plenum Fan sections do not ship with Duct Connections Outlets and Collars from the factory.

- Fan wheels shall be keyed to the shaft and shall be designed for continuous operation at maximum rated fan speed and motor horsepower. Fan wheels and shafts shall be selected with a maximum operating speed 25% below the first critical.

- Fan shafts shall be solid steel, turned, ground, polished and coated with a rust inhibitor.

- Fan motor shall be mounted within the fan section casing on slide rails equipped with adjusting screws. Motor shall be high efficiency, totally enclosed fan cooled NEMA Design B with size and electrical characteristics as shown on the equipment schedule. Premium efficiency motors shall be available. Motor shall be mounted on a horizontal flat surface and shall not be supported by the fan or its structural members. All three-phase motors shall have a ±10% voltage utilization range and a 1.15 minimum service factor. Motor shall be compliant with EPACT where applicable. Single-phase motors shall be available up to and including 5 hp.

b) Performance Ratings:
Fan performance shall be rated and certified in accordance with ARI Standard 430.

c) Sound Ratings:
Manufacturer shall submit first through eighth octave sound power for fan discharge and casing radiated sound.

d) Mounting:
Fan scroll, wheel, shaft, bearings, drives, and motor shall be mounted on a common base assembly. The base assembly is isolated from the outer casing with factory-installed isolators and rubber vibration absorbent fan discharge seal. A canvas style duct connection between fan discharge and cabinet is not acceptable. Units shall use 2-in deflection spring isolators.

e) Fan Accessories:
- o Variable frequency drives
- o Belt guards or Inlet screen.

f) Flexible Connection:
The base assembly is isolated from the outer casing with factory-installed isolators and rubber vibration absorbent fan discharge seal. A canvas style duct connection between fan discharge and cabinet is not acceptable.

.6 Bearings and Drives

a) Bearings

- Self-aligning, grease lubricated anti-friction with lubricating fittings extended to drive side of fan section. Optional grease fittings extended to the exterior of the casing are available.

- Size 06 to110 plenum fans: Heavy duty pillow block type, self-aligning, regreasable roller type bearings selected for a minimum average life (L_{50}) of 200,000 hours or optionally for an (L_{50}) of 500,000 hours.

b) Shafts:
Fan shafts shall be solid steel, turned, ground, polished and coated with a rust inhibitor.

c) V-Belt Drive:
Drive shall be designed for a minimum 1.2 service factor as standard with a 1.5 service factor option and/or a factory-supplied extra set of belts. Drives shall be fixed pitch with optional variable pitch for motors 15 hp and less. All drives shall be factory mounted, with sheaves aligned and belts properly tensioined.

.7 Coils

a) All water, steam and direct expansion (DX) refrigerant coils shall be provided to meet the scheduled performance. All coil performance shall be certified in accordance with ARI Standard 410. All water and direct expansion coils shall be tested at 450 psig air pressure. Direct expansion coils shall be designed and tested in accordance with ASHRAE/ANSI 15 Safety Code for Mechanical Refrigeration (latest edition).

b) General Fabrication:

- All water and refrigerant coils shall have minimum 1/2 in OD copper tubes mechanically expanded into fins to ensure high thermal performance with lower total flow and pumping requirements. Minimum tube wall thickness shall be 0.016 inches. Optional tube wall thickness of 0.025 in. shall be supplied, if specified.

- Optionally, water coils shall have minimum 5/8 in. OD copper tubes mechanically expanded into fins to ensure high thermal performance with lower total flow and pumping requirements. Minimum tube wall thickness shall be 0.020 inches. Optional tube wall thickness of 0.035 in. shall be supplied, if specified.

- Aluminum plate fin type with belled collars. Optional copper plate fins shall be supplied, if specified.

- Aluminum-fined coils shall be supplied with die-formed casing and tube sheets of mill galvanized steel or stainless steel as specified. Copper-finned coils shall be supplied with stainless steel casing and tube sheets.

c) Hydronic Heating and Cooling Coils:

- Headers shall be constructed of steel with steel MPT connections. Headers shall have drain and vent connections accessible from the exterior of the unit. Optional non-ferrous headers and nipples shall be supplied if specified.

- Configuration: Coil shall be drainable, with non-trapping circuits. Coils will be suitable for a design working pressure of 300 psig at 200 F.

.8 Filter Sections

a) Flat filter sections shall accept 4 in. filters. Sections shall include side access slide rails.

b) Angle filter sections shall accept either 2 in. filters of standard sizes, arranged in a horizontal V formation.

c) Filters shall have a minimum efficiency reporting value MERV 13 or higher.

.9 Dampers

a) Mixing boxes, filter-mixing boxes, and exhaust boxes shall have parallel or opposed blades and interconnecting outside-air and return-air dampers.

b) Standards Dampers: Damper blades shall be constructed of galvanized steel, with blade seals and stainless steel jamb seals. Blades shall be mechanically fastened to axle rods rotating in self-lubricating synthetic bearings. Maximum leakage rate shall be 4 cfm/ft^2 at 1 in. wg (0.25 kPa) differential pressure.

.10 Electrical Accessories:

a) Marine Lights and Convenience Outlets:

- Cast, non-ferrous metal, weatherproof, fixture
- Cast, non-ferrous metal, weatherproof, electrical junction box
- Gasketed, heat and shock resistant glass globe protects against moisture and debris
- Cast, non-ferrous metal lamp guard to protect glass globe
- UL listed
- 100 watt type `A' lamp maximum capacity
- Each fixture is equipped with a 75 watt, 130 volt, long life, vibration resistant, lamp (8000+ hour typical lamp life), factory installed
- Metallic, single gang, electrical junction box, UL listed
- With convenience outlet: Factory supplied and wired, SPST, toggle switch and 15 amp, 120 vac/60 Hz, NEMA 5-15 type, ground fault circuit interrupt (GFCI) receptacle, UL listed
- Without convenience outlet: Factory supplied and wired, SPST, UL listed toggle switch
- Each fixture is factory wired to an externally mounted switch box. (Field power connections are made to the switch box mounted externally on the unit).
- All factory wiring penetrating through the panel is protected in `RIGID' type metal conduit.
- 380-575 volt/3-phase fused and non-fused disconnects (Field Supplied) shall have the following characteristics:

- o Visible switch blades with for positive ‘OFF’ indication
- o Quick-make, quick-break operating mechanism
- o Dual cover interlock
- o Color coded ‘ON’ – ‘OFF’ indicator handle
- o Cover padlock hasp and handle lock ‘OFF’ provision for multiple padlocks
- o 600 vac maximum
- o Factory supplied and installed class RK5 fuses (fused disconnects only)
- o Up to 200,000 rms symmetrical amperes SCCR, utilizing appropriately rated, factory-supplied Class R fuses
- o Horsepower rated for motor applications
- o Spring reinforced plated copper fuse clips
- o Tangential combination knockouts
- o NEMA type 1 enclosures
- o Insulated, bondable solid neutral assemblies
- o Wire terminations suitable for aluminum or copper conductors
- o UL listed
- o Meet or exceed NEMA KS1-1999.

b) Variable Frequency Drives:

- Factory-mounted variable frequency drives (VFDs) shall be wired to factory-supplied motors.
- Factory supplied VFDs are programmed and started up from the factory and qualify the VFD, through ABB, for a 24-month warranty from date of commissioning or 30 months from date of sale, whichever occurs first.
- The VFD parameters are programmed into the controller and removable keypad. In the event that the VFD fails and needs replacement, the program can then be uploaded to the replacement VFD via the original keypad.
- The VFD package as specified herein shall be enclosed in a UL Listed Type 1 enclosure, completely assembled and tested by the manufacturer in a facility registered to ISO 9001:2000. The VFD tolerated voltage window shall allow the VFD to operate from a line of +30% nominal, and -35% nominal voltages as a minimum.
  - o Environmental operating conditions: 0 to 40C continuous. Variable frequency drives that can operate at 40C intermittently (during a 24 hour period) are not acceptable and must be oversized. Altitude 0 to 3300 feet above sea level, less than 95%

humidity, non-condensing.

- o Enclosure shall be rated UL type 1 and shall be UL listed as a plenum rated VFD. Variable frequency drives without these ratings are not acceptable.

- All VFDs shall have the following standard features:

  - o All VFDs shall have the same customer interface, including digital display, and keypad, regardless of horsepower rating. The keypad shall be removable, capable of remote mounting and allow for uploading and downloading of parameter settings as an aid for start-up of multiple of VFDs.

  - o The keypad shall include Hand-Off-Auto selections and manual sped control. The drive shall incorporate 'bumpless transfer' of speed reference when switching between 'Hand' and 'Auto' modes. There shall be fault reset and 'Help' buttons on the keypad. The Help button shall include 'online' assistance for programming and troubleshooting.

  - o There shall be a built-in interlock in the VFD keypad. The clock shall have a battery back up with 10 years minimum life span. The clock shall be used to date and time stamp faults and record operating parameters at the time of fault. If the battery fails, the VFD shall automatically revert to hours of operation since initial power up. The clock shall also be programmable to control start/stop functions, constant speeds, PID parameter sets and output relays. The VFD shall have a digital input that allows an override to the time clock (when in the off mode) for a programmable time frame. There shall be four (4) separate, independent timer functions that have both weekday and weekend settings.

  - o The VFDs shall utilize pre-programmed application macros specifically designed to facilitate start-up. The Application Macros shall provide one command to reprogram all parameters and customer interfaces for a particular application to reduce programming time. The VFD shall have two user macros to allow the end-user to create and save custom settings.

  - o The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without requiring removing the VFD from the wall or removal of circuit boards. The VFD cooling fans shall operate only when required. To extend the fan and bearing operating life, operating temperature will be monitored and used to cycle the fans on and off as required.

  - o The VFD shall be capable of starting into a coasting load (forward or reverse) up to full speed and accelerate or decelerate to set point without safety tripping or component damage (flying start).

  - o The VFD shall have the ability to automatically restart after an over-current, over-voltage, under-voltage, or loss of input signal protective trip. The number of restart attempts, trial time, and time between attempts shall be programmable.

- The overload rating of the drive shall be 110% of its normal duty current rating for 1 minute every 10 minutes, 130% overload for 2 seconds. The minimum FLA rating shall meet or exceed the values in the NEC/UL table 430-150 for 4-pole motors.

- The VFD shall have an integral 5% impedance line reactors to reduce the larmonics to the power line and to ad protection from AC line transients. The 5% impedance may be from dual (positive and negative DC bus) reactors, or 5% AC line reactors. Variable frequency drives with only one DC reactor shall add AC line reactors.

- The VFD shall include a coordinated AC transient protection system consisting of four 120-joule rated MOVs (phase to phase and phase to ground), a capacitor clamp, and 5% impedance reactors.

- The VFD shall be capable of sensing a loss of load (broken belt/broken coupling) and signal the loss of load condition. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communications bus. Relay outputs shall include programmable time delays that will allow for drive acceleration from zero speed without signaling a false underload condition.

- If the input reference (4 to 20mA or 2 to 10v) is lost, the VFD shall give the user the option of either (1) stopping and displaying a fault, (2) running at a programmable preset speed, (3) holding the VFD speed based on the last good reference received, or (4) causing a warning to be issued, as selected by the user. The drive shall be programmable to signal this condition via a keypad warning, relay output and/or over the serial communication bus.

- The VFD shall have programmable ‘Sleep’ and ‘Wake up’ functions to allow the device to be started and stopped from the level of a process feedback signal.

- Provide bypass system mounted and wired with the VFD in a self-ventilated, metal, NEMA 1 enclosure with hinged metal door. Bypass shall include three 93) contactors for manual switching from the VFD to line and from Line to VFD, Control Transformer and Class 20 overload relay. When in Bypass Mode the VFD shall be isolated from the line and motor. Door mounted controls shall include the following:

  Command Switches:
  VFD - Off - Bypass Selector Switch
  Hand - Off - Auto Selector Switch
  Hand mode Speed Potentiometer
  Programmable Functions:
  Test Mode (On/Off)
  Auto Bypass (enabled/disabled)
  Auto mode speed reference selector (0-10Vdc or 4-20mA0

  LED indicating lights, Power On, VFD Run, Bypass run, VFD Test Mode, Smoke Purge Activated, Auto Bypass Activated, Interlock open, run permissive open, Motor Overload/Overtmep, VFD Fault.

VFD Keypad; Drive Keypad for setting parameters, control and viewing of Speed, Current and Alarms.

c) All VFDs to have the following adjustments:

- Three (3) programmable critical frequency lockout ranges to prevent the VFD from operating the load continuously at an unstable speed.

- Two (2) PID set point controllers shall be standard in the drive, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control. The VFD shall have 250 mA of 24 vdc auxiliary power and be capable of loop powering a transmitter supplied by others. The PID set point shall be adjustable from the VFD keypad, analog inputs, or over the communications bus. There shall be two parameter sets for the first PID that allow the sets to be switched via a digital input, serial communications or from the keypad for night setback, summer/winter set points, etc. There shall be an independent, second PID loop that can utilize the second analog input and modulate one of the analog outputs to maintain set point of an independent process (i.e., valves, dampers, etc.). All set points, process variables, etc. shall be accessible from the serial communication network. The set points shall be set in Engineering units and not require a percentage of the transducer input.

- Two (2) programmable analog inputs shall accept current or voltage signals.

- Two (2) programmable analog outputs (0 to 20 mA or 4 to 20 mA). The outputs may be programmed to output proportional to Frequency, Motor Speed, Output Voltage, Output Current, Motor Torque, Motor Power (kW), DC Bux voltage, Active Reference, and other data.

- Six (6) programmable digital inputs for maximum flexibility in interfacing with external devices, typically programmed as follows:

  There shall be a run permissive circuit for damper or valve control. Regardless of the source of a run command (keypad, input contact closure, time clock control, or serial communications) the VFD shall provide a dry contact closure that will signal the damper to open (VFD motor does not operate). When the damper is fully open, a normally open dry contact (end-switch) shall close. The closed end-switch is wired to a VFD digital input and allows VFD motor operation. Two separate safety interlock inputs shall be provided. When either safety is opened, the motor shall be commanded to coast to stop, and the damper shall be commanded to close. The keypad shall display Astart enable 1 (or 2) missing.@ The safety status shall also be transmitted over the serial communications bus. All digital inputs shall be programmable to initiate upon an application or removal of 24 vdc.

- Three (3) programmable digital Form-C relay outputs. The relays shall include programmable on and off delay times and adjustable hysterics. Default settings shall be for run, not faulted (fail safe), and run permissive. The relays shall be rated for maximum switching current 8 amps at 24 vdc and 0.4 A at 250 vac; maximum voltage 300 vdc and 250 vac; continuous current rating 2 amps RMS. Outputs shall be true Form C type contacts; open collector outputs are not acceptable.

- Seven (7) programmable preset speeds.

- Two independently adjustable accelerate and decelerate ramps with 1 to 1800 seconds adjustable time ramps.

- The VFD shall include a motor flux optimization circuit that will automatically reduce applied motor voltage to the motor to optimize energy consumption and audible motor noise.

- The VFD shall include a carrier frequency control circuit that reduces the carrier frequency based on actual VFD temperature that allows the highest carrier frequency without operating the VFD or operating at high carrier frequency only at low speeds.

- The VFD shall include password protection against parameter changes.

c) The keypad shall include a backlit LCD display. The display shall be in complete English words for programming and fault diagnostics (alpha-numeric codes are not acceptable). The keypad shall utilize the following assistants:

- Start-up assistants
- Parameter assistants
- Maintenance assistant
- Troubleshooting assistant.

d) All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. The display shall be in complete English words (alphanumeric codes are not acceptable):

- Output Frequency
- Motor Speed (rpm, percentage or engineering units)
- Motor Current
- Calculated Motor Torque
- Calculated Motor Power (kW)
- DC Bus Voltage
- Output Voltage.

f) The VFD shall include a fireman's override input. Upon receipt of a contact closure from the fireman's control station, the VFD shall operate at an adjustable preset speed. The mode shall override all other inputs (analog/digital, serial communication and all keypad commands) and force the motor to run at the adjustable, preset speed. 'Override Mode' shall be displayed on the keypad. Upon removal of the override signal, the VFD shall resume normal operation.

g) Serial Communications:

- The VFD shall have an RS-485 port as standard. The standard protocols shall be Modbus, Johnson Controls N2 bus, and Siemens Building Technologies FLN. Optional protocols for LonWorks7, BACnet, Profibus, Ethernet, and DeviceNet shall be available. Each individual drive shall have the protocol in the base VFD. The use of third party gateways and multiplexers is not acceptable. All protocols shall be certified by the governing authority. Use of non-certified protocols is not allowed.

- o Serial communication capabilities shall include, but not be limited to: run-stop control, speed set adjustment, proportional/integral/derivative (PID) control adjustments, current limit, accelerate/decelerate time adjustments, and lock and unlock the keypad. The drive shall have the capability of allowing the DDC to monitor feedback such as process variable feedback, output speed/frequency, current (in amps), percent torque, power (kW), kilowatt-hours (resettable), operating hours (resettable), and drive temperature. The DDC shall also be capable of monitoring the VFD relay output status, digital input status, and all analog input an analog output values. All diagnostic warning and fault information shall be transmitted over the serial communications bus. Remote VFD fault reset shall be possible. The following additional status indications and settings shall be transmitted over the serial communications bus - keypad "Hand" or" Auto" selected, bypass selected, the ability to change the PID set point, and the ability to force the unit by bypass (if bypass is specified). The DDC system shall also be able to monitor if the motor is running the VFD mode or bypass mode (if bypass is specified) over serial communications. A minimum of 15 field parameters shall be capable of being monitored.

- o The VFD shall allow the DDC to control the drive's digital and analog outputs via the serial interface. This control shall be independent of any VFD function. For example, the analog outputs may be used for modulating chilled water valves or cooling tower bypass valves. The drive's digital (relay) outputs may be used to actuate a damper, open a valve or control any other device that requires a maintained contact for operation. In addition, all of the drive's digital and analog inputs shall be capable of being monitored by the DDC system.

- o The VFD shall include an independent PID loop for customer use. The independent PID loop may be used for cooling tower bypass value control, chilled water value control, etc. Both the VFD control PID loop and the independent PID loop shall continue functioning even if the serial communications connection is lost. The VFD shall keep the last good set point command and last good digital output (DO) and analog output (AO) commands in memory in the event the serial communications connection is lost.

h) EMI/RFI Filters
All VFDs shall include EMI/RFI filters. The onboard filters shall allow the VFD assembly to be CE Marked and the VFD shall meet product standard EN 61800-3 for the First Environment restricted level.

i) All VFDs through 50 hp shall be protected from input and output power mis-wiring. The VFD shall sense this condition and display an alarm on the keypad.

j) Operational Functions:

- The drive shall contain two separate acceleration/deceleration times with auto tuning for optimum setting (0.1 to 6000 seconds) with choice of linear, S, or C curves that shall be factory programmed to match the fan load and prevent nuisance overcurrent fault trips.

- The drive shall be equipped with both local/remote and manual/auto keys on touchpad.

- The drive shall be equipped with a quick setup key.

- The drive shall contain 15 preset speeds, which can be activated from the keypad, terminal inputs and host computer.

- The derive shall have the capability of storable special custom user settings.

- The drive shall restart into a rotating motor operating in either the forward or reverse direction and match that frequency.

- The drive shall have adjustable soft stall (10% to 150%) which reduces frequency and voltage of the inverter to sustain a run in an overload situation factory programmed for each motor's characteristics.

- The drive shall be capable of performing a time base pattern run using 4 groups of 8 patters each using the 15 preset speed values for a maximum of 32 different patterns.

- The drive shall have adjustable UL listed electronic overload protection (10% to 100%) factory programmed to match each motor's FLA/RLA ratings.

- The drive shall have a custom programmable volt/hertz pattern.

k) Protective Features:

- The drive shall be rated for 200,000 AIC. The use of input fuses to achieve this rating shall not be acceptable.

- The drive shall have external fault input.

- The drive shall be capable of resetting faults remotely and locally.

- The drive shall be programmable to alert the following alarms:
  - o Over torque alarm
  - o Inverter overload pre-alarm
  - o Motor overload pre-alarm
  - o Braking resistor overload pre-alarm
  - o Inverter overheat pre-alarm
  - o Undercurrent alarm
  - o Overcurrent pre-alarm
  - o Communication error alarm
  - o Cumulative timer alarm
  - o Executing retry.

- The drive shall identify and display the following faults:
  - o Overcurrent during acceleration trip
  - o Overcurrent during deceleration trip
  - o Overcurrent during normal run trip
  - o Overcurrent on the DC Bus during acceleration trip
  - o Overcurrent on the DC Bus during deceleration trip
  - o Overcurrent on the DC Bus during normal run trip
    Load end overcurrent trip detected at start-up (output terminals, motor wiring, etc)
  - o U-phase short circuit trip detected at start-up
  - o V-phase short circuit trip detected at start-up

- o W-phase short circuit trip detected at start-up
- o Overvoltage during acceleration trip
- o Overvoltage during deceleration trip
- o Overvoltage during normal (constant speed) run trip
- o Inverter overloaded trip
- o Motor overloaded trip
- o Inverter overheat trip
- o Emergency off trip message
- o EEPROM failure during write cycle.
- o EEPROM abnormality during initial reading.
- o RAM error
- o ROM error
- o CPU error
- o Communication interruption error
- o Gage array error
- o Output current detection circuit error
- o Option PCB error trip
- o Low operating current trip
- o Main circuit under voltage trip
- o Over torque trip
- o Software detected earth fault trip
- o Hardware detected earth fault trip
- o Inverter type form mismatch error
- o EEPROM type from mismatch error.

l) Monitor Functions:

- The drive digital display shall be capable of displaying the following: Frequency, percent current, current amps, percent voltage I/O, voltage in volts I/O, RPM, GPM, I/O watts, torque and input reference signal, kWh.

- The drive shall have 320 programmable parameters which can be changed while the drive is operating.

- The drive's 353 parameters shall be adjustable from the 8-key touchpad or computer link.

- The drive's 8-key touchpad shall be NEMA 12 rated.

- The drive's keypad shall be capable of being extended 15 ft. from the drive.

- The drive shall contain a reset of all parameters to factory default settings or user defaults (whichever one is chosen).

- The drive shall have 2 programmable analog outputs programmable to 17 choices.

- The drive shall have one programmable relay output programmable to 67 choices.

- The drive shall have 8 programmable digital inputs programmable to 54 choices.

- The drive shall have a pulse train output proportional to frequency (48, 96, 360 times frequency).

- The drive shall have an elapsed time meter.

2.2 **FANS.**

.1 Dryer Exhaust Fan

a) Supply and install, as shown on the drawings, dryer exhaust fan as manufactured by Kanalflakt. Reversomatic shall be approved equivalent.

b) Exhaust fan shall be of in-line centrifugal, backward inclined type.

c) Round tight housing is of galvanized sheet metal. The motor and impeller are lacquer coated for protection. The motor and impeller are factory manufactured, statically and dynamically balanced as one integral unit, to provide vibration free performance and excellent heat dissipation, even at near zero RPM.

d) The capacitor is enclosed and mounted on the motor bracket. The electrical box is mounted on the fan and has knock-outs for easy electrical hook-up. The blades are backward-inclined to provide maximum efficiency and minimum noise.

e) The motor is a rotating type, totally enclosed, with class B insulation. Sufficient service factor is provided to ensure long and maintenance free operation over maximum load conditions.

f) The motor is capable of operating in air stream temperatures up to 150°F. Ball bearings are to be permanently lubricated and sealed. The motor is 115 Volt, 1 Phase, and 60 CY. The motor is operative on AC current only.

g) The fan is tested and approved by UL, HVI and CSA, or their equivalent, certifying accordance with standards applicable to product classification. Certified performance by AMCA.

h) All motors have automatic reset thermal overload protection. Sizes K4/5 is impedance protected.

i) All fans shall be complete with a ceiling mounted lint trap.

.2 Propeller Wall Fans

a) Supply and install, as shown on the drawing, propeller wall fan as manufactured by Greenheck. Carnes and Reversomatic shall be approved equal.

b) Propeller wall fans shall be of the belt driven type and shall incorporate a heavy duty extruded aluminum airfoil propeller. For fans serving solvent Storage Room and Gas Storage Room, they shall be of direct driven, non sparking type.

c) The propeller shall consist of six extruded aluminum airfoil blades mounted in a cast aluminum hub permitting the replacement of blades without the necessity of replacing the entire propeller. The pitch setting of the blades shall be done at the factory and locked into place by means of a taper lock pin.

d) The fan frame and venturi shall be constructed of heavy gauge painted steel with the fan assembly bolted to the venturi for ease of removal and maintenance. The fan shall be furnished with a double venturi for high efficiencies in both an exhaust and supply mode. Fan bearings shall be of the ball bearing type with a minimum average life of 100,000 hours.

e) All drives shall be designed for 165% of rated horsepower capabilities. Motor drive shall be variable pitch throughout 5 HP and oil resistant belts shall be provided.

f) All fans shall be AMCA certified and licensed to bear the AMCA air seal.

.3 Backward Inclined Centrifugal Fans

a) Supply and install, as shown on drawing, backward inclined centrifugal fans as manufactured by Greenheck. Carnes and Reversomatic shall be approved equivalent.

b) The centrifugal blowers shall be of Rota table belt driven type and single width single inlet. The blower shall be constructed of steel. The power assembly shall be constructed of steel. All seams shall be continuously welded for leakproof assembly. All fans to be Class II.

c) The centrifugal blower shall have a backwardly inclined flat blade blower wheel 2 of the non-overloading type. Blades on all wheels shall be securely welded to both a deep spun inlet shroud and to a spun dished backplate. All wheels shall be carefully trued after assembly and dynamically balanced with balancing weight welded to the wheel. All wheels shall be keyed to the shafts.

d) The blower shafts shall be AISI C-1040 or C-1045 hot rolled and accurately turned and polished. Close tolerances shall be maintained where the shaft makes contact with the bearings.

e) All bearings on the blowers in arrangement ten shall be grease lubricated, precision anti-friction ball self aligning pillow block type.

e) All drives shall be designed for 165% of rated horsepower capabilities and motor drives shall be variable pitch through five horsepower. Oil resistant non-static belts shall be provided.

g) All centrifugal blowers shall be licensed to bear the AMCA seal for air.

h) In general all centrifugal blowers shall include housing, wheel fan shaft, bearings and structural support members as a factory assembled unit. All steel and sheet metal parts shall be cleaned, continued and painted with enamel primer finish prior to final assembly. A final coat of grey enamel shall be applied to all exterior surfaces after assembly.

2.3 GARBAGE CHUTE

.1 Supply and install chute as manufactured by York Sheet Metal Ltd. or approved equivalent. Chutes shall meet all requirements of the authorities having jurisdiction.

.2 Unless otherwise specified on plans, chutes shall be 610 mm dia., 16 gauge aluminum in two sections and one with expansion joint per storey. Chute shall be vertical lockseamed, slip jointed without bolts, clips or rivets. Intake hopper doors shall be mm steel chrome paint plate finished with 305 mm x 380 mm 12 gauge aluminum throat bottom, hinged, automatic, hand operated, self closing, self latching plate doors. Doors shall be complete with baffle door and trim.

.3 Chutes shall extend 1 m above the roof, or as required by local authorities or otherwise shown on the plans. Counter flashing of chute to curb shall be provided under this section. Provide at bottom of chute a Type "A" horizontal sliding fire door with fusible link. Do necessary work for the installation of sprinklers on every second floor starting at top of chute and connection for washdown head. Provide access to sprinklers with removable plate at rear of sprinkler head or through U.L.C. listed access doors provided by this trade.

.4 Provide chute sanitizing washdown system complete with washdown head and control

valves at the top of the chute. Provide all required access doors, and chemical supply for a 6 month period.

.5 WSG-YORK-ICD (integrated chute door) door to be used. All housing of electrical components and push buttons will be incorporated into the WSG-YORK ICD door.

.6 Chutes shall be U.L.C. certified and vibration isolation shall be as per drawings.

PART 3 - EXECUTION.

3.1 AIR HANDLING UNIT INSTALLATION

.1 General: Installing contractor shall install air handling unit(s), including components and controls required for operation, in accordance with air handling unit manufacturer's written instructions and recommendations.

a) Air handling unit(s) shall be stored only in a clean, dry place, protected from weather and construction traffic.

b) Air handling unit(s) shall be handled such that damage to components, enclosure, and finish is avoided.

c) Install in conformance with ARI 435.

d) Isolate fan segments with flexible duct connections.

e) At time of commissioning, replace initial set of pre-filters with clean set.

f) Installing contractor to complete manufacturer's installation checklist prior to startup.

g) Manufacturer to submit a copy of successful startup report to the contractor for submission to owner.

h) Manufacturer to submit six (6) copies of Installation, Operating, and Maintenance manual for use by the owner.

3.2 FANS

.1 Install Rooftop Units in accordance with manufacturer's installation instructions.

.2 Mount units on pre-fabricated factory roof curbs as required. Curbs to be flashed by roofing contractor.

.3 Make all connections to fans utilizing flexible connections.

3.3. GARBAGE CHUTE

.1 Install chute in accordance with manufacturer's installation instructions.

.2 Provide isolation and fire stop as per acoustic report.

PART 1 - GENERAL

1.1 GENERAL REQUIREMENTS.

.1 Conform to the General Provisions of Section 15010.

.2 Provide work under this Section as shown or specified and in accordance with the requirements of the Contract documents.

.3 No CFC-based and HCFC equipment.

.4 HVAC equipment shall meet energy efficiency as listed in ASHRAE 90.1-1999.

1.2 RELATED WORK SPECIFIED ELSEWHERE.

- Basic Materials & Methods Section 15050
- Insulation Section 15180
- Electrical Work Division 16

1.3 SUBMITTALS.

.1 Submit shop drawings in accordance with paragraph 2.2 Section 15010 for major equipment items.

1.4 MODULAR HIGHRISE FANCOIL UNITS

.1 System Descriptions
Stack fan coil units, 2-pipe combination ERV/FCU or 4-pipe FCU, for furred-in cabinets that are floor mounted in multi-storey buildings.

.2 Quality Assurances
Units shall be tested and certified in accordance with ARI standard 440, latest edition. All units shall be UL and CSA approved. Each coil shall be factory tested for leakage at 350 psig air pressure with coil submerged in water. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation. All equipment wiring shall comply with NEC requirements.

.3 Delivery, Storage and Handling
Unit shall be handled and stored in accordance with the manufacturer=s instructions.

1.5 MODULAR HIGHRISE FANCOIL UNITS

.1 System Descriptions
Stack fan coil units, 2-pipe combination HRV/FCU, for furred-in cabinets that are floor mounted in multi-storey buildings.

.2 Quality Assurances
Units shall be tested and certified in accordance with ARI standard 440, latest edition. All units shall be UL and CSA approved. Each coil shall be factory tested for leakage at 350 psig air pressure with coil submerged in water. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation. All equipment wiring shall comply with NEC requirements.

.3 Delivery, Storage and Handling
Unit shall be handled and stored in accordance with the manufacturer’s instructions.

.4 Noise
Suite fan coil sound performance will be measured 2M from the fan coil return air grille in a

furnished suite with the fan coil on medium speed.

1.6 HORIZONTAL TWO PIPE FANCOILS

.1 System Descriptions

Horizontal 2-pipe, belt-driven, galvanized casing model fan coil unit for ducted installation above the ceiling or within floor mounted cabinet, with full access to internal components.

.2 Quality Assurances

- Unit performance shall be rated in accordance with ARI Standard 440-2005.
- Unit construction shall comply with ASHRAE (latest edition) Safety Code and NEC.
- Unit shall be constructed in accordance with ETL and ETL, Canada standards. Factory-installed motors and electric heaters shall be UL approved.
- Each coil shall be factory tested for leakage at 350-psig air pressure with coil submerged in water. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation.
- Each coil shall be factory tested for leakage at 350 psig air pressure with coil submerged in water. Insulation and adhesive shall meet NFPA-90A requirements for flame spread and smoke generation. Factory-installed motors shall be UL approved.

.3 Delivery, Storage and Handling

Unit shall be handled and stored in accordance with the manufacturer's instructions.

1.7 WATER COOLED CENTRIFUGAL CHILLER

.1 System Descriptions

Microprocessor-controlled liquid chiller shall use a single stage, semi-hermetic centrifugal compressors using refrigerant R-134a only. Screw Centrifugal chiller refrigerant shall not have a planned phase out date.

.2 Quality Assurances

- Chiller performance shall be rated in accordance with ARI Standard 550/590.
- Only chillers that are listed in the ARI Certification Program for Centrifugal and Rotary Screw Water Chillers are acceptable.
- Equipment and installation shall be in compliance with ANSI/ASHRAE 15 (latest edition).
- Chiller shall be designed and constructed to meet UL and UL of Canada requirements and have labels appropriately affixed.

.3 Delivery, Storage and Handling

- Unit shall be stored and handled in accordance with manufacturer's instructions.
- Unit shall be completely assembled, with all main, auxiliary and control piping installed, controls wired, leak and air run test completed, and charged with dry nitrogen (2 to 3 psig).
- Oil charge and miscellaneous materials shall be packed separately.
- The initial charge of refrigerant and oil will be supplied, shipped in containers and cylinders for field installation or factory charged in the chiller.
- The refrigerant charge shall be shipped concurrently or separately in cylinders for field evacuation and charging of unit.

.4 Warranty

Warranty shall be parts, labor, and refrigerant for 30 months from date of factory shipment or 24 months from initial startup, whichever is the sooner.

1.8 **DEHUMIDIFIER**

.1 Scope

Provide a packaged energy recycling dehumidifier system designed for natatorium environment control including: dehumidification, pool water heating, air heating, cooling and ventilation.

a. Dehumidification
b. Air heating
c. Air cooling
d. Air filtration
e. Ventilation by Outdoor Air

Unit shall be a Seresco Technologies Ottawa ON. model as shown on drawings and in the specs and schedules. Supplier Kilmer Environmental Inc Mississauga ON 905 890-8908 or equivalent.

.2 Quality and Safety Assurance

a. The unit will be ETL listed.
b. The unit will be completely assembled and tested at the factory with test report available upon request.
c. Live Factory Test: Live remote monitoring of the unit during factory testing shall be available via the Internet.
d. Corrosion: The unit shall be designed to have optimum corrosion resistance with its mechanical vestibule entirely outside of the air stream, along with corrosion resistant coils, pipes, coatings and fan components.
e. Remote Access: Units shall have a microprocessor controller with unit mounted refrigerant pressure transducers on each independent compressor circuit, air pressure transducers across filters and coils, temperature sensors and an **Ethernet** connection for factory monitoring, adjusting and control via the internet.
f. Internet Start-Up assist: The unit shall have remote factory start-up capability via the Internet.
g. The unit shall have **24-7 remote computer monitoring** with automated alarm notifications and system performance alerts. Factory monitoring service shall be provided at no charge to the customer.
h. Warranty: The entire system shall have a 24 month limited parts warranty from ship date.
i. The system shall be covered by an additional 1-year labour warranty when it is connected to the factory via live internet monitoring system from date of initial start-up.
ii. The compressor(s) shall have a 5 year parts warranty from ship date.
i. Serviceability: The unit shall have live remote service capability via the internet with the ability for field service technicians to receive service and trouble alerts via email and make adjustments via smart-phone application remote control. Factory remote service feature shall be provided at no charge to the service group.

1.9 **RADIANT FLOOR HEATING SYSTEMS**

.1 Work Included
Description: Furnish and install a KLIMATROL radiant floor heating (RFH) system as supplied by Klimatrol Environmental Systems Ltd (905)454-1742. Systems shall be

valves, pipe to manifold compression nut fittings, Everloc cold-expansion pipe repair couplings (if required), non-metallic pipe fasteners, manufacturer sized circulators, modulating 3-way mixing valve and slab sensors, installation specialties, supervision and field engineering required for complete and proper function of the system. Alternate systems, utilizing Engel method pex-a must show cost savings.

.2 Regulatory Requirements
Cross-linked polyethylene (PEXa) pipe shall be manufactured by the high-pressure peroxide (Engel) method with a minimum degree of cross-linking of 85%, and conform to ASTM F 876, F 877 and CSA B 137.5. Fittings shall conform to ASTM F 877, F 2080 and CSA B 137.5. Pipe oxygen diffusion barrier shall conform to DIN 4726.

.3 Submittals
a. Provide submittals and shop drawings in accordance with the General Requirements and as specified herein. Submit shop drawings indicating schematic layout of system, including equipment, critical dimensions and piping/slab penetration details as well as details for protecting exposed PEX piping.
b. Submit manufacturer's technical installation instructions.
c. Submit independent certification results for the piping systems from a recognized testing laboratory.
d. Submit computer-generated RFH system design indicating pipe sizing and panel performance at pipe spacing and water temperatures selected. RFH design calculations to be performed on pipe manufacturer’s software.
e. Submit catalog data on all equipment, fittings, fasteners and associated items necessary for the installation of the piping and manifolds.
f. System shall be installed by a contractor experienced in radiant floor cooling / heating system pipe installation. Submit installer’s installation certification and project installation resume of experience.

.4 Delivery, Storage and Handling
a. Deliver and store piping and equipment in shipping containers with labeling in place. Pipe to be kept in original shipping boxes until required for installation. Do not expose pipe to ultraviolet (sunlight) light for more than 90 days.
b. Protect piping and manifolds from entry of contaminating materials by installing suitable plugs in all open pipe ends until installation. Where possible, connect pipes to assembled manifolds to eliminate possibility of contaminants.
c. Piping shall not be dragged across the ground or concrete surfaces, and shall be stored on a flat surface with no sharp edges.
d. Pipe shall be protected from oil, grease, paint, direct sunlight and other elements as recommended by manufacturer.

.5 Warranty
a. The radiant floor heating pipe manufacturer shall warrant the cross-linked polyethylene piping and the “Everloc” fittings if required, to be free from defects in material and workmanship for a period of twenty-five (25) years. The design shall be approved either by submittal or stamped by a registered engineer as being complete and accurate.
b. All manifolds and controls shall be warranted for 18 months and/or two heating seasons.

PART 2 - PRODUCTS.

2.1 **EXPANSION TANK.**

Galvanized steel horizontal compression tank, size and capacity as listed on drawings. Tank shall be designed and constructed in accordance with ASME requirements with a maximum working pressure

of 860 KPa factory supplied with gauge glass and inlet fitting. Acceptable manufacturers S.A. Armstrong, Bell & Gossett.

2.2 **AIR SEPARATOR.**

In line air separator with a maximum working pressure of 860 KPa factory supplied with strainer. Size and capacity as listed on drawings. Acceptable manufacturers, S.A. Armstrong, Bell & Gossett.

2.3 **HEATING BOILER.**

.1 The heating boiler shall be a CAMUS DYNAFLAME, size and capacities as listed on drawing. Acceptable alternatives are Thermal Solution.
The heating boiler shall be design certified by CSA International and shall meet the requirements of ANSI Z21.13, ANSI Z21.10, CSA 4.9 and CSA 4.3. The heating boiler shall be vented as a Category I non-condensing appliance or Category II condensing appliance.

.2 Combustion Chamber

the combustion chamber shall be fully enclosed by a stainless-steel chamber inside of which is assembled a cylindrical copper coil Heat Exchanger having a maximum allowable working pressure of 160 psig (1100 kPa). An access door shall be provided for ease of service and inspection of the Heat Exchanger.

.3 Burner

The burner shall be constructed of stainless steel. The burner shall provide equal distribution of heat through the entire heat exchanger. A window view port shall be provided for visual inspection of the boiler during firing.

.4 Heat Exchanger

The heat exchanger shall be inspected and tested to A.S.M.E. Section IV requirements. The A.S.M.E. Section IV seal of approval will not be provided as standard for jurisdictions not requiring the A.S.M.E. Section IV seal of approval. The heat exchanger shall be a four-pass heat exchanger with maximum working pressure of 160 psig (1000 kPa). The heat exchanger is of cylindrical design, with integral copper finned tube 7/8" I.D., 0.064" minimum wall thickness, 7 fins per inch, with nominal fin height of 3//8". Each end of the tubes shall be expanded by mechanical rolling process into the headers. The heat exchanger shall be gasket-less. All header castings shall be bronze. A pressure relief of valve shall be furnished with the heater.

.5 Control

Standard controls include an electronic proportional integrated combination limit/operator control accurate to 1EF (0.5EC) having a 4-20 mA output signal suitable for control of a variable frequency motor drive. The control shall also provide readouts of boiler target, differential and inlet/outlet temperatures as well as accumulated runtime. On/off switch, and full diagnostic light package shall be provided. The complete control package shall be mounted on the front panel with hinged door for each access to all control modules. A flow switch shall be provided loose. To be compatible with Siemens FLN protocol.

.6 Firing Mode

The burner shall operate as fully modulating down to 35% of the heating load. Light off shall be at no more than 50% input to assure rumble free soft start.

.7 Venting Options

The following venting options shall be utilized: 1. Standard Venting. 2. Horizontal & Vertical Outside air Venting. 3. Through-Wall Venting. 4. Outdoor Venting. 5. Direct Venting.

.8 Gas Train

The gas train shall consist of a gas valve with a pressure regulating electro-hydraulic actuator to provide slow opening, fast closing, safety shutoff and air/gas ratio control. A factory pre-set combination metering valve and orifice shall be provided for setting combustion parameters.

.9 Ignition Module

The ignition module shall employ a proved igniter with 3 tries for ignition and with 1 hour reset. Trial for ignition shall be 10 seconds with 15 seconds between retrials.

.10 External jacket and Fasteners

The external jacket shall be of stainless steel mirror finish panels assembled utilizing interference fit locks and minimal non-strip self tap screws.

2.4 **COOLING TOWER.**

.1 General: Furnish and install one (1) factory-assembled, induced draft, crossflow cooling tower with vertical air discharge, conforming in all aspects to the specifications, schedules and as shown on the plans. Overall dimensions shall not exceed approximately 8' long X 18' wide X 9'-10" high. The total connected fan horsepower shall not exceed 10 HP. The cooling tower shall be Baltimore Aircoil Company Model XES3E-8518-05K.

.2 Thermal Capacity: The cooling tower shall be warranted by the manufacturer to cool 720 USGPM of water from 95 ºF to 85 ºF at 76 ºF entering wet bulb temperature plus 12% spare capacity. Additionally, the thermal performance shall be certified by the Cooling Technology Institute in accordance with CTI Certification Standard STD-201. Lacking such certification, a field acceptance test shall be conducted within the warranty period in accordance with CTI Acceptance Test Code ATC-105, by the Cooling Technology Institute or other qualified independent third party testing agency. Manufacturers' performance guarantees or performance bonds without CTI Certification or independent field thermal performance test shall not be accepted. The cooling tower shall have a base energy rating that meets or exceeds two times that of the minimum ASHRAE 90.1 energy rating.

.3 Corrosion Resistant Construction: Unless otherwise noted in this specification, all steel basin panels and structural members shall be constructed of heavy-gauge G-235 hot-dip galvanized steel with all edges given a protective coating of zinc-rich compound.

.4 Quality Assurance: The cooling tower manufacturer shall have a Management System certified by an accredited registrar as complying with the requirements of ISO9001:2008 to ensure consistent quality of products and services. Manufacturers that are not ISO9001 Certified shall not be acceptable.

.5 Wind and Seismic Forces: The structure shall be designed, tested and certified in accordance with IBC 2009.

.6 Structure: The cooling tower shall be constructed with a sturdy structural frame designed to transmit all wind, seismic and mechanical loads to the equipment anchorage. The frame shall be constructed of heavy-gauge steel angles and channels.

.7 Casing Panels: Casing panels shall be constructed of corrosion and UV-resistant fiberglass reinforced polyester (FRP) to minimize maintenance requirements and prolong equipment life. Casing panels shall not provide structural support, since the sturdy, structural frame of the tower transfers all loads to the equipment anchorage.

Corrosion resistant Type 304 stainless steel casing panels may be used in lieu of FRP panels.

.8 Cold Water Basin: The cold water basin shall be constructed of heavy-gauge steel panels and structural members. Basin shall include a depressed center section with drain/clean-out connection. The basin area under the fill shall be sloped toward the depressed center section to facilitate cleaning. Standard basin accessories shall include a corrosion resistant make-up valve with large diameter plastic float for easy adjustment of the operating water level, removable anti-vortexing device to prevent air entrainment, and large area lift out strainers with perforated openings sized smaller than the water distribution system nozzles.

.9 Water Outlet: The water outlet connection shall be beveled for welding and grooved for mechanical coupling or bolt hole circle designed to accept an ASME Class 150 flat face flange. The outlet shall be provided with large-area lift out strainers with perforated openings sized smaller than the water distribution nozzles and an anti-vortexing device to prevent air entrainment. The strainer and vortex device shall be constructed of the same materials as the cold water basin to prevent dissimilar metal corrosion.

.10 Water Distribution System: The hot water distribution basins shall be the open and gravity fed for easy cleaning, and constructed of heavy-gauge, G-235 hot-dip galvanized steel. The basins must be accessible from outside the unit and serviceable during tower operation. Basin weirs and plastic metering orifices shall be provided to assure even distribution of the water over the fill. Weir dams shall accommodate a flow range of 50% to 100% of the design flow rate. Lift-off distribution covers shall be constructed of heavy-gauge G-235 hot-dip galvanized steel and designed to withstand a 50 psf live load or 200 pound concentrated load. Gravity flow nozzles shall be snap-in type for easy removal. Should pressurized nozzles be used, they shall utilize grommets, which ensure easy removal.

.11 Fan: Fan shall be heavy-duty, axial flow with aluminum alloy blades selected to provide optimum cooling tower thermal performance with minimal sound levels. Air shall discharge through a fan cylinder designed for streamlined air entry and minimum tip clearance for maximum fan efficiency. The top of the fan cylinder shall be equipped with a conical, non-sagging removable fan guard.

.12 Bearings: Fan and shaft shall be supported by heavy-duty, self-aligning, grease-packed ball bearings with moisture proof seals and integral slinger collars, designed for a minimum L_{10} life of 80,000 hours.

.13 Fan Drive: The fan shall be driven by a one-piece, multi-groove, solid back V- type powerband with taper lock sheaves designed for 150% of the motor nameplate horsepower. The powerband shall be constructed of neoprene reinforced polyester cord and be specifically designed for cooling tower service.

.14 Sheaves: Fan and motor sheave(s) shall be fabricated from corrosion-resistant materials to minimize maintenance and ensure maximum drive and powerband operating life.

.15 Fan Motor: Fan motor shall be totally enclosed air over (TEAO), reversible, squirrel cage, ball bearing type designed specifically for cooling tower service. The motor shall be furnished with special moisture protection on windings, shafts and bearings. Fan motors shall be premium efficient/inverter duty type designed per NEMA Standard MG1, Section IV Part 31.

.16 Mechanical Equipment Warranty: The fan(s), fan shaft(s), sheaves, bearings, mechanical equipment support and fan motor shall be warranted against defects in materials and workmanship for a period of five (5) years from date of shipment.

.17 Fill and Drift Eliminators: The fill and integral drift eliminators shall be formed from self-extinguishing (per ASTM-568) polyvinyl chloride (PVC) having a flame spread rating of 5 per ASTM E84 and shall be impervious to rot, decay, fungus and biological attack. The fill shall

be suitable for entering water temperatures up to and including 130°F. The fill shall be manufactured, tested and rated by the cooling tower manufacturer and shall be elevated above the cold water floor to facilitate cleaning.

.18 Air Inlet Louvers: Air Inlet louvers shall be separate from the fill and removable to provide easy access for inspection of the air/water interface at the louver face. Louvers shall prevent water splash out during fan cycling and be constructed of maintenance free, corrosion and UV resistant, fiberglass reinforced polyester (FRP).

.19 Plenum Access: Two hinged access doors shall be provided for access into the plenum section.

.20 Sound Level: To maintain the quality of the local environment, the maximum sound pressure levels (dB) measured 50 ft from the cooling tower operating at full fan speed shall not exceed the sound levels detailed below. If the tower exceeds these conditions the tower must be either oversized and reduced in horsepower, provided with a low sound fan, or provided with sound attenuation.

Top: 61 dBA Air Inlet: 60 dBA End: 55 dBA

.21 Balancing Valves: Heavy-duty butterfly valves shall be provided at the hot water inlet connections. These valves shall include cast iron bodies, elastomer seat and steel operating stems. There shall be a locking handle to maintain the valve setting in any position. Wafer type field supplied spool piece is required between the inlet connection and the valve.

.22 Fan Deck Ladder: An aluminum ladder with galvanized steel safety cage shall be provided for access to the fan deck. Access door or service platforms are not acceptable. Ladder/cage shall be provided with extension to suit cooling tower structure.

.23 Handrails: 1-1/4" galvanized steel pipe handrail shall be provided around the perimeter of the cooling tower cells. The handrails shall be provided with knee and toe rails and shall conform to the requirements of OSHA applicable at the time of shipment. Ladder opening shall be provided with safety gate.

.24 Internal Walkway: An internal walkway shall be provided in the plenum section to provide for inspection and maintenance. All working surfaces shall be able to withstand 50 psf live load or 200 pound concentrated load. Other components of the cooling tower, i.e. basin and fill/drift eliminators, shall not be considered an internal working surface.

.25 Fan Motor Variable Frequency Drive: The cooling tower manufacturer shall provide one (1) loose 10 HP fan motor variable frequency drive in NEMA 1 enclosure. VFD shall be provided with main power disconnect switch, drive input fuses, 3-contactor bypass, input DC line choke, input DC link reactor, hand/off/auto control, LCD display, dual input PID controller, and Siemens FLN protocol.

2.5 MODULAR HI-RISE FANCOIL UNITS

.1 Furnish and install, as shown on drawing, two pipe vertical heat recovery fancoil unit as manufactured by Airia IVS series. UNILUX to be approved equivalent.

.2 Capacity - Unit capacities shall be certified in compliance with Air Conditioning and Refrigeration Institute Standard 440-89.
Safety - Units listed with Underwriters Laboratory Standard UL 1995.

.3 Construction

- The unit shall include an all steel cabinet of multi-bend panel construction to maintain strength and alignment. Standard cabinet is fully insulated with ½" thick multi-density matte-faced glass fiber insulation and is designed to allow a maximum combination of

supply and return air arrangements. Supply of openings is sized for individual air delivery requirements to provide optimum velocity for quiet operation and proper air throw. Return air openings are sized to give quiet operation while allowing full access to internal components.

- Standard features shall include internal piping from the coil and drain pan to the risers. This factory piping includes Aexpansion loops@ as required to accommodate moderate riser expansion as a standard feature. Each water coil shall include a manual air vent to allow venting at the coil for quicker more complete air elimination. All piping and valves packages are fully leak tested to assure system integrity after installation.

- The condensate drain pan is fabricated of galvanized steel and coated inside with closed cell, fire retardant foam insulation. The drain shall be factory piped to the drain riser with a removable “P-trap” to allow easy cleaning when required.

- The motor/blower assembly shall be direct drive type with the motor mounted directly to the blower housing. This allows the entire assembly to be easily removed from the unit without disturbing the blower wheel and motor alignment. Mounting the motor in the direct path of the blower airflow provides maximum motor cooling and extends motor life.

- Each unit includes a glass fiber throwaway filter sized for low velocity and maximum efficiency. The easily removable filter is positioned to filter both room return air and outside air.

.4 Cabinet

Single units are to be designed for concealed installation and are fabricated of heavy gauge galvanized sheet steel of multi-bend, braced construction and include a full riser chase enclosure. These units are designed to have the wall board applied directly to the unit surface and all openings have standard ½“ drywall flanges. No framing around opening is required. After installation, only the thermostat, supply, and return grilles are visible. Units with two supply air openings may be furnished with a sight and sound baffle between openings to suit jobsite ducting.

.5 Coils

Coils are constructed with ½ " O.D. copper tubes with aluminium fins mechanically bonded to the tubes. All coils are leak tested with an air under water test and are suitable for design working pressures of 250 psig @ 200°F.
A maximum total row available is five. Unit to have 2 pipe heating/cooling coil.

.6 Risers

Risers are to be Type “L” seamless copper and include a 3" long up-sized or swaged section at the top to accept the riser from above without requiring a coupling. This waged section is designed for a 2" insertion depth to assure field joint integrity. One piece risers are to be provided. All risers including the drain are to be insulated with closed cell foam pipe insulation in ½ " thickness. This insulation covers the full riser length and does not require field furnished insulation at the field joints. The standard insulation has an NFPA flame spread and smoke development rating of 25/50.

Riser diameters to match size progression as shown on the drawings.

.7 Fans

Blower wheels are to be centrifugal type; forward curved double-width, double-inlet; sized for maximum efficiency and quiet operation. Blower housings are fabricated of galvanized steel with special rolled lock-seam or spot welded construction to provide maximum rigidity and reliable performance.

.8 Motors

Each motor is specifically designed to deliver the required performance for an individual

application. All motors are resilient-mounted, ECM, with Underwriters Laboratory listed thermal overload device built-in to protect the motor against excess current draw and overheating.

Motor bearings are of the sleeve type with oversized oil reservoirs provided to assure positive lubrication with minimum servicing required.

.9 Valves
Control valves (3 way as per blueprints) shall be factory installed with 115V/1/60 actuator and manual shut off valves.

.10 Controls
Remote 24 volts thermostat and aquastat control supplied by manufacturer and wired by mechanical contractor. Conduit by electrical control.

.11 Electric Heater
1.5kw electric heater 115V/1/60 shall be factory installed with necessary control and wirings.

.12 Drain pan overflow safety switch to be provided.

.13 ERV Specifications:

a) CASE 22 gauge galvanized steel. Size 19-1/4" x 35-1/2" x 9". Cabinet should be fully insulated with 1" (25 mm) aluminium-foil face fibreglass to prevent condensation and meet the requirements of the UL and local building code.

b) MOTOR: Two fans, shall install ECM motors which can automatically balance themselves to pre-set CFM in case of pressure variations due to stack-effect, wind-effect or duct friction loss. They should be permanently lubricated sealed ball bearings to guarantee long life and maintenance-free operation. Motors should have 2 factory pre-set speed (which is adjustable depending on request). The default low speed is 40/70 CFM; default high speed is 100/160 CFM. Max E.S.P. to run against is 0.8"/0.5" WC.

c) TIMER CONTROL: Supplied by Unilux, installed in bathroom by the others, the time base is 20-40-60 minutes.

d) CORE: Cross flow polymeric energy recovery core (enthalpy); Size is 12'x12"27".

e) FILTERS: Provide best available filter, MERV 7 or better.

f) DEFROST: A preset 6 minutes defrost sequence is activated when outdoor air temperature is below 23°F (-5°C). During the defrost sequence, the motorized damper will shut down the air intake ports, and simultaneously open the internal recirculation port to allow hot air from fan coil unit to regenerate the core, and maximize the effectiveness of ventilator. The unit then returns to normal operation for 20 minutes, and continues cycle; in extreme weather if the temperature is below -15°F (-25°C), it will run 10 minutes defrost and 20 minutes normal operation, then repeat the cycle.

g) DUCT CONNECTION: 5"/6" plastic duct connections.

h) DRAIN: Drain pan on the bottom, c/w 2 pieces 3/8: OD (outside diameter) drain connection.

i) SEQUENCE OF OPERATION: The ERV OA and EA fans will run continuously at low speed when switching on the unit. The defrost cycle will start when the outside temperature drops below -5°C. Turning on the bathroom timer will automatically jump the ERV to High-Speed for the selected period. For 2-bathroom suite c/w 2 timers, turning on either or both timers will jump the ERV to high speed for the longer selected period. The activation of bathroom timer will override defrost cycle.

j) PERFORMANCE:

- 0°C sensible recovery efficiency @ nominal airflow (100/160 CFM): 69/65%.
- 0°C latent recovery efficiency @ nominal airflow (100/160 CFM): 43/32%.
- 35°C sensible recovery efficiency @ nominal airflow (100/160 CFM): 79/73%.
- 35°C latent recovery efficiency @ nominal airflow (100/160 CFM): 36/25%.

` .14 Thermostat
Programmable heating/cooling thermostat /w humidity read-out "Honeywell TB7100A1000 or approved equal to be provided.

2.6 HORIZONTAL TWO PIPE FANCOILS

.1 General
Factory-assembled, horizontal, draw-thru or blow-thru type fan coil unit for ducted installation above the ceiling or floor mounting. Unit shall be complete with water coils, fan(s), motor, belt drive, drain pan and filter.

2 Casing
Construction shall be heavy-gage galvanized steel, lined with minimum 1/2 in. thick fibreglass Tuf-Skin II thermal/acoustical insulation. Knockouts shall be provided for hanging the horizontal unit that will accept 3/8 in. threaded rod at the top, and bottom of all unit corners. Supply and return duct connection shall be 1 in. long. Removable side panels shall be provided for access to the fan/motor assembly. A double-sloped drain pan shall be constructed of stainless steel, extending under the full length and width of the coil(s) with a 3/4 in. male nominal pipe thread stainless steel drain connection and 2 in. male MPT stainless secondary drain connection (capped when not required). The outside surface of the drain pan shall be insulated with 1/8 in. closed cell insulation.

.3 Fans
Belt-driven, double-width fan wheels shall have forward-curved blades and be statically and dynamically balanced. Fan drive shall consist of variable-pitch motor pulley, fixed-pitch fan pulley and V-belt. Fans and scrolls shall be of galvanized steel.

.4 Coils
Standard unit shall be equipped with a 4-row coil for installation in a 2-pipe system and additional rows of coil shall be provided for installation in a 4-pipe system as described in the Options and Accessories section. Coils shall have 2 in. copper tubes; aluminium fins bonded to the tubes by mechanical expansion and have a working pressure of 250 psig at 200F. Each coil shall have a manual air vent and sweat connections for copper tubes.

.5 Operating Characteristics
A single-circuit coil unit installed in a 2-pipe system shall be capable of providing heating or cooling as determined by the operating mode of the central water supply system. A double-circuit coil unit installed in a 4-pipe system shall be capable of providing sequenced heating and cooling.

.6 Motor(s)
Fan motors shall be open, drip-proof, single-speed, 60 Hz, 1750 rpm **1 phase**, suitable for continuous duty at 104F (40C). Single phase motors are capacitor start, include automatic reset thermal overload protection and are available in 115, 208, 230 or 277 volts (60 Hz). Three-phase motors are available in 208, 230 or 460 volts (60 Hz). Motors are resilient base mounted (except 3 and 5 hp motors, which are rigid base mounted). Belt drive motors shall be high efficiency, direct drive motors shall be ECM type.

.7 Options and Accessories
Factory-installed Options: 1

Coils:
- Unit coil(s) shall be equipped with automatic air vent(s).
- Unit shall be equipped with changeover hydronic coil plus DX coil as denoted on the drawings.
- Cooling duty coils shall be copper tube, aluminum fin.

Filters:
- A **MERV 13** pleated filters shall be installed in the unit (standard) per drawings remarks.

Insulation:
- Units shall be equipped with minimum 1/2 in. thick Tuf-Skin II insulation (standard).

Controls:
- Unit shall be equipped with 24-v transformer, motor contactor and terminal strip for connection to field or factory provided controller.
- Unit shall be equipped with interlocking door-disconnect switch, touch-type fusing, 24-v transformer, motor contactor and terminal strip for connection to field provided controller.
- Unit shall be equipped with interlocking door-disconnect switch, separate motor and electric heater touch-type fusing, 24-v transformer, motor contactor and terminal strip for connection to field or factory provided controller.

Motor(s):
- Single-phase motors are capacitor start and shall include automatic reset thermal overload protection and shall be available in 115, 208, 230 or 277 volts (60 Hz). Three-phase motors shall be available in 208, 230 or 460 volts (60 Hz).

2.7 **MODULAR HI-RISE FANCOIL UNITS.**

.1 General

Factory assembled, stack fan coil units. Units are complete with water coil(s), fan(s), motor(s), drain pan, and all required wiring, piping, controls and special features.

.2 Furred-In Stack Unit (42SG)

The unit shall be constructed of 18-gage galvanized steel frame and 18-gage galvanized steel back panel. The fan coil is open or enclosed for furred-in installation. These units are designed to have the wallboard applied directly to the unit surface and all openings have standard 2 in. thick fibreglass Tuf-Skin II insulation. Units have double deflection aluminium discharge grille(s) and painted, stamped (standard) or bar-type aluminium (optional) return-air grille panel. Removable return-air grille provides access to all internal piping and wiring. Controls are provided with a quick disconnect plug for field-mounting on front of unit.

.3 Drain Pan

Drain pan shall be formed of 18-gage steel and shall be coated inside with fire-retardant closed-cell foam insulation. Water never touches the metal pan eliminating the possibility of corrosion. The drain is factory piped to the drain riser that has a removable “P-trap” allowing easy cleaning.

.4 Filter

A filter track complete with 1-in. **permanent** filter shall be installed in the unit. Filters of units with a maximum flow rate of more than 600 cfm shall have a minimum efficiency reporting value MERV 13 or higher. Filters of units with a maximum supply volume of 600 cfm or less shall complete with the highest supply air filtration level commercially available for the specific equipment.

.5 Fan

- Centrifugal fan shall be directly-driven by an electric motor.
- Fan wheel shall be double-width type with forward-curved blades and shall be statically and dynamically balanced.
- Fan wheel and scroll shall be constructed of galvanized steel.

.6 Coil

- Standard base unit shall be equipped with a 3-row for installation in a 2-pipe system. Additional coil depth and circuiting shall be provided for installation in a 4-pipe system as described in the Special Features section.

- All coils shall have ½ in. copper tubes and aluminium fins spacing; coil fins are mechanical bonded to tube joints. The copper tubes comply with the ASTM B-75. The fin thickness is 0.0045-in. And tube thickness is 0.016-in. All coils are tested with air under water and are suitable for design working pressures of 250 psig at 220°F. Burst tested at 350 psig.

- Coil shall be equipped with a manual air vent and shall be piped to supply and return risers with valves a specified on the equipment drawings.

- Piping between coil and risers shall include loops to compensate for maximum riser expansion and contraction of 1-1/2 inches.

.7 Risers

- Standard factory-furnished and installed risers shall be 104 in. long with 3-in. belled ends at the top such that only one sweat connection shall be required at each floor to join one riser to another.
- Risers shall be Type M copper insulated with 1 in. thick fibreglass insulation.

- Standard supply and return risers shall be 1-1/4 in. diameter; drain riser shall be 1 in. diameter.

.8 Valves

The factory furnished and installed piping shall include two ball valves and one 2-way motorized valve except at the bottom and top floors of each zone where piping shall include two ball valves and one 3-way motorized valve. The ball valves shall be rated at 250 psig.

.9 Controls and Safeties

- Controls
  Standard controls for a 2-pipe system shall consist of a 3-speed fan switch, heating/cooling thermostat (SPDT) and an automatic changeover device.
  Unit controls shall be mounted behind the access door on the return air panel.

- Safeties
  Unit fan motor shall be equipped with integral motor protection.

.10 Operating Characteristics

- A unit with a conventional coil, installed in a 2-pipe system, shall be capable of providing heating or cooling as determined by the operating mode of the central water supply system.

- A unit with a low-split coil installed in a 4-pipe system, shall be capable of providing sequenced heating and cooling.

.11 Electrical Requirements

Standard unit shall operate on 115-v, single phase, 60-Hz electrical power supply.

.12 Motor

- Fan motor shall be 3-speed, 115-v, single phase, 60-Hz, permanent split capacitor type, factory mounted on the blower housing.

- Bearings shall be of the sleeve type with oil tubes and oversized oil reservoir to assure positive lubrication and minimum service requirements.

.13 Optional Features

- Unit coil shall be equipped with automatic air vents.

- Unit shall be equipped with a 4-row coil for installation in a 2-pipe system.

- For installation in a 4-pipe system, unit shall be equipped with:
  a. A 3/1, 3/2 or 4/1 row-split coil, as shown on equipment drawings for cooling and heating.
  b. Two each supply and return risers and one 1 in. diameter drain riser.

- Supply and return risers shall be 1 in., 1½ in., 2 in. or 2½ in. diameter as shown on the equipment drawings.

- Floor-to-floor height of risers shall be as specified on the equipment drawings.

- Drain riser shall be Type DWV copper.

- One-in. thick cleanable filters shall be installed in the filter track.

  Unit shall be equipped with nichrome wire electric strip heaters for total or auxiliary electric heat as specified on the equipment schedule.
  a. Heaters shall be protected by an automatic reset safety cutout switch and a fusible link.
  b. Heater capacity shall be specified on the equipment schedule.
  c. Heaters shall be single phase, 60 Hz for 120, 208, 240 or 277 volts as specified on the equipment schedule.
  d. For total electric heat, unit controls shall include a sequenced heating and cooling thermostat in lieu of the heating/cooling thermostat and automatic changeover device.
  e. For auxiliary electric heat, unit controls shall include 2 additional automatic changeover devices. A junction box and fuse shall be factory-furnished and installed to protect the motor and control circuit when electric heaters are installed in a unit with a single power source.

- Fused or unfused disconnect switch shall be provided for field installation. Switch shall be suitable for single phase, 60 Hz service for 115, 208, 240 or 277 volts as specified on the equipment schedule.

- Panels of 42SH unit shall be painted with the colour specified on the equipment schedule.

- Tamper-proof fasteners (Allen head) shall be installed on the access panels on cabinet models.

- A stainless steel drain pan shall be available for factory installation.

- Factory-installed installation options shall include antimicrobial coated, dual density fibreglass or foil faced fibreglass installation.

.14 Combined ERV/FCU

- Motor: One motor for fresh air intake. Motor should be factory-balanced EBM PSC motor with forward curved blades. It should be permanently lubricated sealed ball bearings to guarantee long life and maintenance-free operation. Motor should have 2-speed, low speed between 35CFM – 45CFM; high speed regulate to 75CFM to avoid airflow variation due to pressure changes.

- Exhaust fan & timer control: Exhaust fan supplied and installed in bathroom by the others, it needs to be PSC type. Bathroom timer supplied by Unilux and installed by others, bathroom timer is 20-40-60 time base. The maximum power of EA fan is 115W if connected to Unilux control box. The bathroom fan should be sized to 75CFM@1.6"WC in high speed, considering the friction loss of air ducts and HRV and stack-effect. In low speed, the fan will be electronically adjusted to 40-45CFM.

- Core: Cross flow polymeric energy recovery core (enthalpy); Size is 12'X12"X7".

- Filters: For HRV/ERV units under 600 cfm; MERV 6 (minimum) pre-filters with MERV 7 (best available) final filters. For fan coil units under 600 cfm; MERV 6 (minimum) pre-filters with MERV 11 (best available) final filters. For HRV/ERV and FCU units over 600 cfm; MERV 8 (minimum) pre-filters with MERV 13 (best available) final filters.

- Defrost: A preset 6 minutes defrost sequence is activated when outdoor air temperature is below 23°F (-5°C). During the defrost sequence, the motorized damper will shut down the air intake ports, and simultaneously open the internal recirculation ports to allow hot air from fan coil unit to regenerate the core, and maximize the effectiveness of ventilator. The unit then returns to normal operation for 20 minutes, and continues cycle; in extreme weather if the temperature is below -15°F (-26°C), it will run 10 minutes defrost and 20 minutes normal operation, then repeat the cycle.
- Duct Connection: 5" plastic duct connections for designed air flow rate 75 CFM and below.

- Air flow regulators should be installed on supply and exhaust ports to maintain constant 75 CFM.

- Drain: Drain pan on the bottom, c/w 2 pieces 3/8" OD (outside diameter) drain connection.

- Sequence of Operation: Switch on bathroom timer will automatically jump to High-Speed mode. The activation of bathroom timer can override defrost cycle; fan will jump to "High" mode automatically.

- Speed Control: automatically switch to high speed when defrost cycle activated:

    - Intermittent: 20 minutes low speed operation, 40 minutes off.
    - Low: Continuously on low speed, between 35-45 CFM which can be adjusted electronically.
    - High: Continuously on high speed, 75 CFM.
    - Off.

- Performance:
    - 0°C sensible recovery efficiency @ nominal airflow (75CFM): 71%.
    - 0°C latent recovery efficiency @ nominal airflow (75CFM): 50%.

- 35°C sensible recovery efficiency @ nominal airflow (75CFM): 81%.
- 35°C latent recovery efficiency @ nominal airflow (75CFM): 40%.

2.8 SPLIT SYSTEM HEAT PUMPS

.1 General
Factory-assembled, horizontal, draw-thru type fan coil unit for ducted installation above the ceiling or floor mounting. Unit shall be complete with DX coils, fan(s), motor, drain pan and filter

2 Casing
Construction shall be heavy-gage galvanized steel, lined with min 1/2-in. thick fibreglass Tuf-Skin II thermal/acoustical insulation. Knockouts shall be provided for hanging the horizontal unit that will accept 3/8 in. threaded rod at the top, and bottom of all unit corners. Supply and return duct connection shall be 1 in. long. Removable side panels shall be provided for access to the fan/motor assembly. A double-sloped drain pan shall be constructed of stainless steel, extending under the full length and width of the coil(s) with a 3/4 in. male nominal pipe thread stainless steel drain connection and 2 in. male MPT stainless secondary drain connection (capped when not required). The outside surface of the drain pan shall be insulated with 1/8 in. closed cell insulation.

.3 Fans
Direct drive or Belt-driven, double-width fan wheels shall have forward-curved blades and be statically and dynamically balanced. Fan drive shall consist of variable-pitch motor pulley, fixed-pitch fan pulley and V-belt. Fans and scrolls shall be of galvanized steel.

.4 Coils
Standard unit shall be equipped with a DX coil for installation in a 2-pipe system shall have 2 in. copper tubes; aluminium fins bonded to the tubes by mechanical expansion

.5 Operating Characteristics
A single-circuit coil unit installed in a 2-pipe system shall be capable of providing heating or cooling as determined by the operating mode of the matching heat pump unit. A double-circuit coil unit installed in a 4-pipe system shall be capable of providing sequenced heating and cooling.

.6 Motor(s)
Fan motors shall be open, drip-proof, single-speed, 60 Hz, 1750 rpm **1 phase**, suitable for continuous duty at 104F (40C). Single phase motors are capacitor start, include automatic reset thermal overload protection and are available in 115, 208, 230 or 277 volts (60 Hz). Three-phase motors are available in 208, 230 or 460 volts (60 Hz). Motors are resilient base mounted (except 3 and 5 hp motors, which are rigid base mounted). Belt drive motors shall be high efficiency, direct drive motors shall be ECM type.

.7 Filters:
- A **MERV 13** pleated filters shall be installed in the unit (standard)., per dwg remarks

Insulation:
- Units shall be equipped with a min ½". thick Tuf-Skin II insulation (standard).

Controls:
- Unit shall be equipped with 24-v transformer, motor contactor and terminal strip for connection to field or factory provided controller.
- Unit shall be equipped with interlocking door-disconnect switch, touch-type fusing, 24-v transformer, motor contactor and terminal strip for connection to field provided controller.
- Unit shall be equipped with interlocking door-disconnect switch, separate motor and electric heater touch-type fusing, 24-v transformer, motor contactor and terminal strip

for connection to field or factory provided controller.

Motor(s):

- Single-phase motors are capacitor start and shall include automatic reset thermal overload protection and shall be available in 115, 208, 230 or 277 volts (60 Hz). Three-phase motors shall be available in 208, 230 or 460 volts (60 Hz).

.8 Outdoor heat pump section

Units shall be supplied with min 14.5 SEER performance including low ambient cooling in case cooling is required in colder ambient temperatures.

.9 Basis of design is Johnson Controls

2.9 **WATER COOLED SCREW CHILLER**

.1 General

a. Unit shall be completely factory-packaged including evaporator, unit mounted VFD starter, condenser, sub-cooler, compressor, motor, lubrication system, control center and all interconnecting unit piping and wiring.

b. Unit shall be painted prior to shipment.

c. Refrigerant to be R-134a.

d. Water chiller to be packaged electric twin VFD screw compressor machine with compressor, evaporator, water cooled condenser, 575V power transformer for unit mounted variable frequency drive, controls, piping, wiring, and refrigerant and oil charge.

e. Basis of design is York YVWA. Carrier and McQuay are acceptable alternates, providing they meet the specified requirements.

.2 Performance

a. Capacity per equipment schedule.

b. Machine selection to be based on maximum fluid velocity of 8fps in condenser and evaporator and fouling factor of 0.00025 sq.ft. EF/Btu/hr condenser and 0.0001 sq.ft. EF/Btu/hr in evaporator. Water side shall be designed for 150 psig working pressure.

c. Chiller efficiency to meet CSA C743 efficiency std with additional limits denoted above.

.3 Compressors

a. Compressors: Shall be direct drive, semi hermetic, rotary twin-screw type, including: terminal box, and precision machined cast iron housing. Design working pressure of entire compressor, suction to discharge, shall be 450 psig (31 barg) or higher. Compressor shall be U.L. recognized.

b. Compressor Motors: Refrigerant suction-gas cooled accessible hermetic compressor motor, full suction gas flow through 80 mesh screen, with inher-ent internal thermal protection and external current overload on all three phases.

c. Balancing Requirements: All rotating parts shall be statically balanced.

d. Lubrication System: External oil separators with no moving parts, 388 psig (26.8 barg) design working pressure, and ETL listing shall be provided on the chiller. Refrigerant system differential pressure shall provide oil flow through service replaceable, 0.5 micron, full flow, cartridge type oil filter. Filter bypass, less restrictive media, or oil pump not acceptable.

e. Capacity Control: Compressors shall start at minimum load. Provide Microprocessor control to command compressor capacity to balance compressor capacity with cooling load.

.4 Evaporator:

a. Evaporator shall be shell and tube, hybrid falling film type to optimize efficiency and refrigerant charge. Tubes shall be high-efficiency, internally and externally enhanced type copper tubes with 0.035″ (0.89 mm) minimum wall thickness at all intermediate tube supports to provide maximum tube wall thickness at the support area. Each tube shall be roller expanded into the tube sheets providing a leak proof seal, and be individually replaceable.

b. Constructed, tested, and stamped in accordance with applicable sections of ASME pressure vessel code for minimum 235 psig (16 barg) refrigerant side design working pressure and 150 psig (10 barg) liquid side design working pressure.

c. Water boxes shall be removable to permit tube cleaning and replacement. Liquid nozzle connections shall be ANSI/AWWA C-606. Companion flanges, bolts, nuts, and gaskets are not included.

d. Connection location: Chilled liquid inlet and outlet nozzle connections shall be located as shown on schedule.

.5 Condenser:

a. Condenser shall be shell and tube type, with a discharge gas baffle to prevent direct high velocity impingement on the tubes and to distribute the refrigerant gas flow evenly over the tubes. An integral sub-cooler shall be located at the bottom of the condenser shell providing highly effective liquid refrigerant subcooling and highest cycle efficiency.

b. Constructed, tested, and stamped in accordance with applicable sections of ASME pressure vessel code for minimum 388 psig (26.8 barg) refriger-ant side design working pressure and 150 psig (10 barg) liquid side design working pressure.

c. Water boxes shall be removable to permit tube cleaning and replacement. Liquid nozzle connections shall be ANSI/AWWA C-606. Companion flanges, bolts, nuts, and gaskets are not included.

d. Connection location: Chilled liquid inlet and outlet nozzle connections shall be located as shown on schedule.

.6 Insulation

a. Material: Closed-cell, flexible, UV protected, thermal insulation complying with ASTM C 534 Type 2 (Sheet) for preformed flexible elastomeric cellular thermal insulation in sheet and tubular form.

b. Thickness: 3/4" (19mm) for Evaporator.

c. Thermal conductivity: 0.26 (BTU/HR-Ft2-°F/in) maximum at 75°F mean temperature.

d. Factory-applied insulation over cold surfaces of liquid chiller components including evaporator shell, water boxes, and suction line. Liquid nozzles shall be insulated by Contractor after pipe installation.

e. Adhesive: As recommended by insulation manufacturer and applied to 100 percent of insulation contact surface including all seams and joints.

.7 Acoustical Data

a. Provide unweighted sound power or sound pressure level data in decibels (dB) at the scheduled eight (8) octave band center frequencies. A-weighted sound data alone is not acceptable.

b. Provide all sound power or sound pressure level data at 100%, 75%, 50%, and 25% load.

c. Supplied equipment shall not exceed scheduled sound power or sound pressure level data at any load point. The mechanical Contractor shall be responsible for any additional costs associated with equipment deviation.

d. Acoustical performance shall be evaluated in accordance with AHRI Standard - 575 test data.

e. Provide factory-installed sound reduction treatment to meet specified chiller sound levels scheduled at all load points.

.8 Power And Electrical Requirements

a. Power/Control Panel:

1. Factory installed and wired NEMA 1, powder painted steel cabinets with tool lockable, hinged, latched, and gasket sealed outer doors equipped with door latch. Provide main power connection(s), compressor starters, current overloads, and factory wiring.

b. Single Point Power:

1. Provide single point power connection to chiller, shall be 3 phase of scheduled voltage.

2. Single Point Circuit Breaker: A unit-mounted Circuit Breaker with external lockable handle shall be supplied to isolate power voltage for servicing. Incoming power wiring must comply with local codes. Circuit breaker shall be sized to provide chiller equipment with the branch circuit protection, short circuit protection.

c. Control Transformer: Power panel shall be supplied with a factory mounted and wired control transformer that will supply all unit control voltage from the main unit power supply. Transformer shall utilize scheduled line voltage on the primary side and provide 115V/1Ø on secondary.

d. All exposed power wiring shall be routed through liquid-tight non-metallic conduit.

e. Supplied equipment shall not exceed scheduled Minimum Circuit Ampacity (MCA.) The mechanical Contractor shall be responsible for any additional costs associated with equipment deviation.

f. A 575V transformer shall be provided to supply power to the chiller.

.9 Controls

a. General:

1. Provide automatic control of chiller operation including compressor start/stop and load/unload, anti-recycle timer, evaporator pump, condenser pump, evaporator heater, condenser heater, unit alarm contacts and run signal contacts.

2. Chiller shall automatically reset to normal chiller operation after power failure.

3. Unit operating software shall be stored in non-volatile memory. Field programmed set points shall be retained in lithium battery backed regulated time clock (RTC) memory for minimum 5 years.

4. Alarm controls shall be provided to remote alert for any unit or system safety fault.

b. Display and Keypad:

1. Provide minimum 80 character liquid crystal display that is both viewable in direct sunlight and has LED backlighting for nighttime viewing. Provide one keypad and display panel per chiller.

2. Display and keypad shall be accessible through display access door without opening main control/electrical cabinet doors.

3. Display shall provide a minimum of unit setpoints, status, electrical data, temperature data, pressures, safety lockouts and diagnostics without the use of a coded display.

4. Descriptions in English (or available language options), numeric data in English (or Metric) units.

5. Sealed keypad shall include unit On/Off switch.

c. Programmable Setpoints (within Manufacturer limits): Display language, chilled liquid cooling mode, local/remote control mode, display units mode, system lead/lag control mode, remote temperature reset, remote current limit, remote heat recovery kit, leaving chilled liquid setpoint and range, maximum remote temperature reset.

d. Display Data: Chilled liquid leaving and entering temperatures; lead system; flow switch status; evaporator/condenser pump status; active remote con-trol; evaporator pressure, discharge, and oil pressures, condenser and economizer pressures per refrigerant circuit; economizer temperature and superheat; subcooler liquid temperature and superheat; compressor discharge temperature and superheat, motor; temperatures, educator temperature, per refrigerant circuit; compressor speed, condenser level, condenser level control valve; economizer superheat; economizer feed valve percentage open, evaporator/condenser heater status; oil pump status; compressor number of starts; run time; operating hours; evaporator and condenser

heater status; history data for last ten shutdown faults; history data for last 20 normal (non-fault) shutdowns.

e. Predictive Control Points: Unit controls shall avoid safety shutdown when operating outside design con-ditions by optimizing the chiller controls and cooling load output to stay online and avoid safety limits being reached. The system shall monitor the following parameters and maintain the maximum cooling output possible without shutdown of the equipment: motor current, evaporator pressure, condenser pressure, discharge pressure, starter internal ambient temperature, and starter baseplate temperature.

f. System Safeties: Shall cause individual compressor systems to perform auto-reset shut down if: high discharge pressure or temperature, low evaporator pressure, low motor current, high/low differential oil pressure, low oil level, low discharge and economizer superheat, smart freeze point protection, high motor temperature, system control volt-age, educator clog.

g. Unit Safeties: Shall be automatic reset and cause compressors to shut down if:, low leaving chilled liquid temperature, under voltage, flow switch operation. Contractor shall provide flow switch and wiring per chiller manufacturer requirements.

h. Manufacturer shall provide any controls not listed above, necessary for automatic chiller operation. Mechanical Contractor shall provide field control wiring necessary to interface sensors to the chiller control system.

i. A Modbus or BACnet MSTP communication e-link shall be provided for single twisted pair communication to BAS system

.10 Startup and Operator Training:

a. The services of a factory trained, field service representative shall be provided to supervise the final leak testing, charging and the initial startup and conduct concurrent operator instruction.

.11 Isolation Mounting:

a. Unit shall include four vibration isolation mounts, consisting of heavy duty spring isolators (see vibration isolation specs) for field mounting.

b. The pads are to be mounted under the steel mounting pads on the tube sheets. Suitable for ground floor installation.

.12 Maintenance Contract

Provide service by manufacturer's technician to maintenance the chiller for the first 2 years from date of initial startup.

Inspect chiller and VFD starter , operational check, refrigerant leak test, lubricate motors. Repair chiller to first class condition..

At the end of each cooling season:
- remove condenser water box ends and brush clean condenser tubes, tighten electrical connections, megger compressor motor windings, perform oil analysis and report, replace oil filter and driers, change oil as needed

Provide emergency response to minimize downtime

2.10 **CHEMICAL TREATMENT.**

.1 Closed Re-Circulating System (Chilled, Heating and Glycol Loops)

Provide complete water treatment equipment and chemicals for corrosion protection and side stream filtration for each closed system.

a. One (1) Chemical By-Pass Feeder, 2 US gal capacity, steel construction with a working pressure of 300 psi.

b. One (1) By-Pass Filter Unit with the capacity to handle 2.5 - 5% of the total recirculation pump flow rate and capable of operating at the system pressure. Provide 1 case of 30 pcs Cartridge Filter, 10 inches, 20 microns. Filter shall be supplied with a flow indicator to indicate filter replacement at no flow condition.

c. Two (2) Corrosion test coupons, one copper and one steel.

d. Provide Cabinet and test kit for measuring inhibitor level.

e. Provide sufficient chemical cleaner (WMC/GE Ferroquest FQ7103) for flushing/cleaning each closed system and sufficient corrosion inhibitor (WMC/GE Corrshield NT4207 Inhibitor) for initial treatment plus1 month consumption after turnover of the system.

.2 Each glycol system to include water treatment equipment as indicated under paragraph .1, with the addition of an Automatic Glycol Feed System (WMC/MX-2045). The feed system consists of the following:

a. 50 US Gallon Polyethylene Storage Tank complete with hinged cover.

b. Rotary bronze gear pump, 1/3 HP, 2.0 gpm, 75 psi.

c. Control Panel consist of H-O-A switch for gear pump with indicator light, push alarm test button, slider silence button c/w low level and indicator light for pump protection, power switch and light, pressure switch to activate the glycol feed control panel.

d. Provide sufficient glycol to fill the glycol feed unit after the systems are charged with glycol formulated for HVAC system.

e. Provide glycol test kit to test glycol concentration.

.3 Open Re-Circulating System (Cooling Tower, Fluid Cooler (Spray Water).

.1 For each Open System, provide complete packaged automatic Chemical Control System on Wall-mounted Polyethylene Backboard pre-piped and pre-wired (WMC WCT410STD Series) consist of the following:

a. One (1) Walchem Controller WCT410-1N2U with Flow Switch or Equivalent.

b. Two (2) Walchem Chemical Pump, 0.6 GPH, 150 psi, 115 VAC or Equivalent.

c. One (1) Stenner Peristaltic Pump, 17 GPD, 100 psi, 115 VAC or Equivalent.

d. One (1) Solenoid or Motorized Valve, sized for bleed-off control.

e. System above complete with strainer, inlet/outlet piping comes with unions for ease of installation.

f. One (1) Contact Head Make-Up Water Meter, sized to system requirements (remote installation.

g. One (1) Totalizing Water Meter for bleed water monitoring.

h. One (1) Chemical By-Pass Feeder, 2 US Gal capacity.

.2 Provide sufficient scale/corrosion inhibitor (WMC/GE Gengard GN8142) and 2 alternating biocides (WMC/GE Spectrus NX1106 and Spectrus OX1205C) for initial treatment plus1 month consumption after turnover of the system. All chemicals are fed directly from their shipping pails.

.3 Provide all necessary test equipment for testing inhibitor and bleed-off levels.

2.11 HORIZONTAL UNIT HEATERS

.1 General
Furnish and install, where indicated or scheduled on plans, Eng Air, Sterling or approved equal hot water unit heaters. Unit shall be equipped as specified herein. All units shall be installed in a neat and workmanlike manner in accordance with this specification and the manufacturer's installation instruction.

.2 Casing
Casings shall be 20 gauge die-formed steel. Casing substrates shall be prepared for finishing with a hot wash, iron phosphatizing clear rinse, chromic acid rinse and oven drying. Paint finish shall be of lead-free, chromate free, alkyd melamine resin base and applied with an electrostatic two-pass system. Finish shall be baked at 350EF.

.3 Coil
Coil elements and headers shall be of heavy wall drawn seamless copper tubing. Element tubes shall be brazed into extruded header junctions. Pipe connection saddles shall be of cast bronze. Aluminum fins shall have drawn collars to assure permanent bond with expanded element tubes and exact spacing. All Element Assembles are submersion tested at factory at 250 P.S.I., and are rated at 75 pounds of saturated steam pressure at 366EF, under maximum load conditions. We recommend operating pressure of 75 P.S.I. at 320EF for long life.

.4 Motors
Motors shall be totally enclosed, resilient mounted with class AB@ windings. All motors shall be designed for horizontal mounting. Motors under 1/3 H.P. are totally enclosed, frame mounted, 115/1/60 with thermal overload protection and permanently lubricated sleeve bearings with optional solid state speed controller available. 1/3 H.P. (115/1/60) motors are open frame construction, with thermal overload protection and ball bearings. 1/3 H.P. at (230V) and 2 H.P. (230V) motors are open frame construction, with thermal overload protection and ball bearings. 1/3 and 2 H.P. motors are available in single and 3 phase in open frame construction or explosion-proof housings, all the above are available as options.

.5 Fans
Fans shall be of the aluminum blade, steel hub type designed and balanced to assure maximum air delivery, low motor horsepower requirements and quiet operation. Blades are spark proof.

.6 Fan Guards
Fan guards shall be welded steel, zinc plated or painted. OSHA fan guards are optional.

.7 Air Deflection Louvers
Units shall be equipped with horizontal, individually adjustable louvers. Vertical louvers for four-way air control shall be available as an optional extra.

2.12 **FINNED TUBE HEATER**

.1 Furnish and install where shown on all plans/drawings, Eng Air, Sterling or approved equal Finned-Tube Assemblies as described in the specifications below.

.2 All copper/aluminum heating elements shall be manufactured with seamless copper tubing mechanically expanded into the diameter of the equally spaced aluminum fins. The ends of the copper tube shall be of finished O.D. (male) and finished I.D. (female, swaged) as to allow the use of standard domestic copper fittings.

.3 All full backplates will be one piece construction, 20 gauge galvannealed steel (18 gauge optional) with a die-formed mounting channel into which the enclosure shall self-locate and secure. Mounting slots shall be provided for both top and bottom mounting holes in the mounting brackets. Self-adhesive sponge air seal gasket to be provided when noted.

.4 All brackets and hangers are to be die-formed 14 gauge galvannealed steel with channel type wiped edge construction for rigidity. Nickel-chromium plated ball bearings inserted into a nylon isolator insert are to be used in conjunction with an 18 gauge galvannealed die-formed element support cradle to provide friction free lateral movement during expansion and contraction. Brackets are to have pre-formed contour at the top allowing the bracket to interlock with the backplate channel. Brackets are to be self-locating in the vertical position. Full engagement enclose locks are to be supplied with each bracket.

2.13 **REFRIGERANT MONITOR SYSTEM**

.1 Units shall be certified to UL and CSA standards. Manufacturer shall be certified ISO-9001-2000. Vulcain is basis of design. MSA is acceptable alternate.

.2 System to consist of one (1) Master Panel Controller for inside the mechanical room, one (1) remote slave panel for outside the mechanical room, one (1) infrared Refrigerant Specific Gas Sensor, and Power Transformer. Master and Slave panel to have audible and visual alarms.

.3 The master control panel must be capable of communicating digitally with the networked transmitters and relay modules through three RS-485 Modbus communication buses. Each communication bus must be capable of accepting a combination of up to 32 addressable transmitters, relay modules or annunciator panels at a maximum distance of 2,000 feet. One power supply (bringing either 17-27 Vac or 24-38 Vdc) shall be sufficient to power the entire gas detection network (controller and sensors).

The control panel shall manage four internal DPDT relays at fully programmable alarm levels (and within programmable time delays) and be capable of activating multiple relay modules of eight relays each. The relay rating will be no lower than 5A, 30 Vdc (resistive load).

The control panel must include a self-test function that allows for the activation/deactivation of all the programmed outputs by simulating a continuous 5% increase/decrease value until the maximum/minimum value is reached.
The control panel must include a real-time clock that enables operation of the outputs for a specific timeframe.

The control panel will be capable of communicating with an annunciator panel that can serve as a remote display panel in a secondary control room.

The control panel will indicate the exact concentration of gas, the gas detected, and the

location of the sensor by sweeping through the network and displaying the detected levels at each point on a graphic LCD display.

The LCD display will indicate multiple alarm levels for each sensing point. The LED will also provide visual feedback in the following manner:

Normal Operation:	Green LED
Alarm Level A:	Red LED
Alarm Level B:	Red LED
Alarm Level C:	Red LED
Failure:	Yellow LED
TX:	Yellow LED
RX:	Green LED

The standard three high/low alarm levels will be complemented with multiple levels that can be programmed into the panel at a later dated.

The panel will have an audible alarm incorporated (rated at no less than 65 dBA at three feet) which will be activated at fully programmable levels.

The control panel will leave the factory fully programmed and will be adjustable in the field by keying in instructions via the keypad. Programming must be saved on its Flash memory card. Suitable for operation between -4°F and 122°F, the control panel must be housed in a NEMA 4 cast aluminum enclosure.

The unit will be certified to UL and CSA standards. The controller must be manufactured within an ISO 9001 production environment.

The control panel must be a Vulcain model VA301CDS controller equipped with the BDCM data communication module manufactured by Vulcain Alarm Inc.

.4 Refrigerant Gas Sensor will be powered by the VA-301EM expansion module. Refrigerant gas will enter the infrared gas detection chamber according to the diffusion principle. The gas sensor will have resolution levels of 1 ppm with a standard range of 0-1000 ppm. Temperature and relative humidity variations will have no effect on the unit's accuracy.

The sensor will be capable of operating within relative humidity ranges of 5-95% and temperature ranges of 32°F-100°F (0°-40°C).

The unit will be equipped with a Nema 4X Polycarbonate-ABS impact-resistant housing. The unit will be manufactured to UL and CSA standards. The controller must be manufactured within an ISO 9001 production environment.

2.14 PLATE AND FRAME HEAT EXCHANGERS

Supply and install, where shown on drawings, plate and frame heat exchanger(s). Armstrong type PFX is basis of design. Manufacturer to optimize and guarantee heat transfer using specified capacity and pressure drop conditions to shown on schedules.

.1 General
The exchanger shall have one-piece interplate gaskets made of materials suitable for the given fluids and process conditions. Compressed asbestos or gaskets with no memory are not acceptable.

.2 Process
The exchanger shall be of counterflow design to accommodate thermal duties with possible temperature cross. The nozzle size shall be that required for distribution of fluid within the plates. Any reduction/enlargement in nozzles shall be done in process piping. Nozzle

velocities shall not exceed 20 ft/sec for liquids and 300 ft/sec for vapours.

.3 Mechanical
All heat transfer surfaces must be accessible for mechanical cleaning. Plate corrugation for the entire plate shall be pressed in a single stroke of the press. All connections greater 2.5" shall be studded port. Connections 2.5" and less shall be threaded.

.4 Materials
The exchanger shall be made with heat transfer plates in 304 or 316 stainless steel. Gaskets shall be suitable for system fluids, either EPDM or Nitrile. Tie rods, nuts and washers shall be zinc plated. Balance shall be epoxy coated carbon steel.

.5 Fabrication
The exchanger design, materials and fabrication shall conform to the latest version of the ASME code Section VIII Division 1.

.6 Testing
Completed heat exchanger shall be hydrostatically tested to one and one third the design pressure in accordance with code.

2.15 **DEHUMIDIFIER**

.1 General

Natatorium Environment Control System: Furnish a natatorium control system as follows:

a. Remote air-cooled condenser
b. Indoor configuration –horizontal cabinet
c. Mechanical process dehumidification
d. Air heating type: hot water coil
e. Air filtration type: 2-inch pleated filters
f. Minimum Outdoor Air connection: damper & filter remote mounted by others
g. Programmable microprocessor controller with Live, 24-7 remote internet access, monitoring and control.
h. Unit shall have a service vestibule where the compressor, refrigeration specialties and control valves and all electronics are outside of process air stream.

.2 Principle of Operation

a. Unit shall be designed and sized to maintain the specified conditions. The unit operation shall be as follows:

1. The humid air from the natatorium passes through the dehumidifying coil and is cooled below its dew point, thereby condensing moisture.
2. The moisture removed at the evaporator coil shall be greater than or equal to the space latent load.
3. The heat captured by this process and the heat generated by the compressor power consumption is absorbed by a mechanical refrigeration system.

b. Mode of Operation:

1. Dehumidification (Full Reheat): When the space is calling for heat, 100% of the compressor hot gas condenses at the reheat coil. The supply air temperature is ~ 15 ºF warmer than the return air.
2. Dehumidification (Neutral Reheat): When the space temperature is within the dead-band range, the compressor excess heat is rejected in parallel to the reheat and air condenser coils. The supply air temperature is approximately equal to the return air temperature. Air Conditioning: While in air conditioning

mode, any excess heat shall be rejected via an Outdoor air-cooled condenser.

3. Air heating: When air temperature in the space falls below the set point and the compressor air reheat is insufficient, the auxiliary air heater is activated. The air heating controls are modulated.

.3 Cabinet

a. The cabinet and structural materials used in the cabinet shall meet the following standards:

1. Base Rails: The cabinet shall have a base frame formed using formed 12 gauge mill galvanized G90 steel and allow access to the drain connection.
2. Cabinet Construction: The cabinet shall be single-wall construction with 1-inch insulation.
3. Floors: The cabinet floor shall be mill applied, 2-coats of paint to 20-gauge mill galvanized G90 steel and shall be mechanically fastened to the base frame of the unit.
4. Walls/Roof: The cabinet walls and roof shall be engineered with structural bending for maximum rigidity with mill applied, 2-coats of paint to 20-gauge mill galvanized G90 steel and shall be mechanically fastened to the floor of the unit.
5. The cabinets shall be mechanically assembled with stainless steel 5/32" sealed pop rivets. Where bolts are required bright zinc plated bolts shall be used.
6. Doors: Access doors shall be secured to cabinet using heavy-duty stainless steel hex-head bolts with stainless steel washers insulated with rubber gaskets.

b. Insulation: The unit shall be insulated per the following standards:

1. Surface coated with an anti-microbial layer, protected against perforation and fiber air entrainment with a reinforcing mesh.
2. Fire resistant rating to conform to NFPA Standard 90A and 90B.
3. Sound attenuation coefficient shall be not less than 1.00 at a frequency of 1,000 Hz as per ASTM Standard C423.
4. Thermal conductivity shall not exceed 0.23 Btu/in-h-sqft-F at 75 F.

c. Cabinet configuration shall include:

1. Horizontal, single-wall, standard layout.
2. A built in return air filter rack with separate access door suitable for 2inch filters.
3. Unit shall be equipped with duct collars to admit outdoor air in compliance with ASHRAE Ventilation Standard 62. The outdoor air intake filter and damper are field supplied and installed by others.
4. Mechanical vestibule: The unit shall have the compressor, blower motor, receiver, solenoid valves and the electrical panel in a separate compartment out of the processed air stream. All components shall be serviceable while the unit is in operation without disturbing the airflow.
5. Electrical panel: The unit shall have a built-in electrical control panel in a separate compartment in order not to disturb the airflow within the dehumidifier during electrical servicing. All electrical components shall be mounted on a 16 gauge galvanized sub-panel.

d. Filtration: Standard sized, replaceable, off-the-shelf filters used throughout including:

1. Return Air: 2-Inch MERV 8, 30% pleated filters with rust-free non-metallic structure

2. Outside Air: 2-Inch MERV 8, 30% pleated filters with rust-free non-metallic structure

.3 Coils

a. Evaporator/dehumidifier coils shall conform to the following standards:

1. Coils shall be fully dipped and coated with a polyester/enamel coating for maximum corrosion protection. Coating shall comply with ASTM B117/D1654 and ASTM D2126 for corrosion resistance against common acids, salt and gases.
2. Coil shall have 18-gauge galvanized casing and end plates.
3. Aluminium fin and copper tubes mechanically bonded to assure high heat transfer.
4. Leak test: Factory tested at pressures not less than 600 psig

b. Air reheat condenser coils shall conform to the following standards:

1. Coils shall be fully dipped and coated with a polyester/enamel coating for maximum corrosion protection. Coating shall comply with ASTM B117/D1654 and ASTM D2126 for corrosion resistance against common acids, salt and gases.
2. Coil shall have 18-gauge galvanized casing and end plates.
3. Aluminum fin and copper tube joints mechanically bonded to assure high heat transfer
4. Leak test: factory tested at pressures not less than 600 psig

.5 Drain Pans

The evaporator coil shall be provided with a positive draining, compound-sloped, baked powder paint coated aluminum drain pan with fully-welded corners to ensure zero water retention.

.6 Blowers and Blower Motors

Supply blowers shall conform to the following standards:

a. Rust-impervious, high-performance composite materials used for blower wheel.
b. Blower wheel is backward-inclined, single width/single inlet airfoil plenum type.
c. Integrated, asynchronous external rotor motor.

.7 Compressors

a. Type: Scroll type, suction gas cooled, suitable for refrigerant R-410A
b. The compressors shall be mounted on rubber in shear isolators to prevent transmission of any noise and vibration to the space below.
c. Removable crankcase heater for liquid migration protection.
d. Compressors shall be located outside the conditioned air stream.
e. Compressors shall have a 3-year warranty extension for a total of 5 years coverage.
f. Compressor manufacturer must have a wholesale outlet for replacement parts in the nearest major city.

.8 Refrigeration Circuit

a. The unit shall consist of one refrigeration circuit for humidity and/or air conditioning control.
b. Refrigeration circuit shall have pressure transducers monitoring the refrigerant high and low pressures. The refrigeration circuit shall be accessible for diagnostics,

adjustment and servicing without the need of service manifold gauges.

c. Shall have solenoid control valves, check valves, a liquid line filter drier, liquid and moisture indicator, thermostatic expansion valve and pump down solenoid valve.
d. Unit shall have an externally adjustable balanced port design mechanical thermostatic expansion valve. The valve shall have a removable power head.
e. Tamper proof, hermetically sealed non-adjustable high and low pressure controls and refrigeration service valves shall be installed using Schrader type valves. Refrigeration service valves shall be located outside of the airstream.
f. Receiver shall have two refrigerant level (maximum and minimum) indicating sight glasses.
g. Suction line shall be fully insulated with ½ inch closed cell insulation.

.9 Control Panel

a. Electrical contractor shall be responsible for external power wiring and disconnect switch fusing. Power block terminals shall be provided.
b. Shall be mounted inside the service vestibule outside of the process air stream.
c. Blower motors shall be protected with thermal trip overloads.
d. Unit shall have a voltage monitor with phase protection.
e. Available dry contacts shall include:
    1. Alarm
    2. Blower interlock
    3. Stage 1 & 2 heating
    4. Outdoor air damper control
    5. Remote exhaust fan #1
    6. Remote exhaust fan #2
    7. Outdoor-air cooled equipment
    8. System on
    9. Auxiliary pool heater 1
    10. Auxiliary pool heater 2
    11. Heat recovery
f. Terminals shall be provided for 24 volt power to the outdoor air cooled condenser fan contactor.
g. All wiring shall be installed in accordance with UL or CSA safety electrical code regulations, and shall be in accordance with NFPA. All components used shall be UL or CSA listed.
h. Color-coding and wire numbering shall be provided for easy troubleshooting. All wires shall be in a wire duct. Wiring diagrams located near electrical panels on unit.
i. Compressors shall have a time delay start to prevent short cycling.
j. Pressure transducers for refrigerant high pressure and suction pressure shall be provided.
k. Airflow switch and dry contact for alarm shall be provided.

.10 Microprocessor Control

a. A microprocessor controller with the following characteristics will be provided:
    1. All set points and adjustments are preprogrammed at the factory during quality control and test operation.
    2. The microprocessor program has an updatable FLASH memory.
    3. The Flash memory will be updatable via an internet connection.
    4. A minimum: 11 Analog inputs, 4 Analog outputs, 24 Digital inputs and 16 Digital outputs.
    5. Four serial interface ports including both RS232 and RS485 types.
    6. An Ethernet port with RJ-45 connector and LED activity indicator.
    7. A real time clock to time stamp unit operation log with programmable 7-day occupied/unoccupied scheduling capabilities.
    8. Two manual demand forced modes to allow user a manual bypass of the microprocessor in the event of controller failure.

9. Keypad and display panel shall have a backlit graphic liquid crystal display.

b. Unit shall have pressure transducers monitoring the refrigerant high and low pressures. The refrigeration circuit shall be accessible for diagnostics, adjustment and servicing without the need of service manifold gauges.

c. The following status LEDs shall be on the controller:

1. Alarm - indicates there has been a failure requiring service.
2. Dehumidification - indicates that the system is dehumidifying the space.
3. Cooling - indicates that the air-conditioning mode.
4. Space Heat - indicates that the space heating is operating.
5. Maintenance - indicates whether or not maintenance is required.
6. Manual - indicates that the system has been set to manual operation.

d. The following set points shall be accessible and adjustable from the display panel:

1. Space temperature
2. Space relative humidity

e. The following sensors shall be unit-mounted and monitored at the display panel:

1. Refrigerant high pressure
2. Refrigerant low pressure
3. Return air temperature
4. Supply air temperature
5. Return air relative humidity
6. Evaporator leaving air temperature
7. Suction temperature
8. Discharge temperature

f. System Fault: Shall indicate via text message to the display what systems require attention or servicing. Built-in monitoring and diagnostics shall allow the user to view the following:

1. Power Failure
2. Dirty air filter
3. Refrigerant high and low pressure
4. System off
5. Anti-short cycle delay

.11 Air Heating

Unit mounted hot water heating coil shall be sized to meet the scheduled capacity and have the following characteristics:

a. Modulating control.
b. Coils shall be fully dipped and coated with a polyester/enamel coating for maximum corrosion protection. Coating shall comply with ASTM B117/D1654 and ASTM D2126 for corrosion resistance against common acids, salt and gases.
c. Coil shall have 18-gauge galvanized casing and end plates.
d. Fin and tube joints mechanically bonded to assure high heat transfer.
e. Fin material: Aluminum
f. Tube material: Copper
g. Leak test: factory tested at pressures not less than 400 psig

.12 Air Conditioning

Air-cooled air conditioning

a. Unit shall be equipped with air conditioning mode where excess compressor heat is rejected to a remote air-cooled condenser. The air-cooled condenser shall be capable of rejecting 100% of the compressor heat rejection with an air on temperature at summer design conditions. The condenser shall be equipped with a 24VAC control including contactor for fan motor.
b. Unit shall be provided with a dry contact rated for 24VAC/5A to operate the remote condenser control. Refrigeration circuit shall include solenoid refrigerant valves, receiver with pressure relief valve set at 650 psig, pressure control valve, pressure differential valve, two manual shutoff valves to isolate the outdoor condenser.
c. The remote air-cooled condenser coils shall have copper tubes expanded into a aluminum fins. Coils shall be tested at 600 PSIG and mounted vertically for complete surface utilization. Coils shall be counter flow with a minimum of 10 degrees of liquid sub-cooling and have adequate capacity to dissipate the total heat rejection of the system at design conditions. Condensers shall have guards to protect the coils from vandalism and weather related damage.
d. Condenser fans shall be coated steel and have a steel hub locked on a stainless steel motor shaft with a keyway and square head set screws.
e. Fans shall be low RPM and have a radius spun type venturi for quiet (40-50 dBA) and efficient performance. Fans shall have vinyl coated external guards capable of being removed for service without removing the fan motor.
f. Fans shall be direct driven by NEMA constructed motors. Each motor shall have a shaft slinger to prevent water seepage into the motor.

.13 Control Sequence

a. When system is powered supply fan shall start and interlocked motorized fresh air damper shall open.
b. Interlocked pool area exhaust fan to run continuous with unit.
c. On a rise in return air humidity the controller starts the compressors according to demand. Heat rejection is controlled by the integral room air and water temperature sensors. In dehumidification demand all hot gas will be diverted to the reheat coil. When compressors are operating excess heat not required by the pools contributes to the room heating through a full sized integral air-cooled refrigerant reheat condenser. In a multiple compressor system, each compressor stage is turned on based on a proprietary predictive algorithm
d. On a drop in entering pool water temperature and if the compressor(s) is already operating from a Dehumidification or Air Conditioning demand, the solenoid valves divert the compressor refrigerant hot gas through the coaxial pool heat exchanger and the balance of compressor heat is rejected at either the reheat coil or outdoor condenser.
e. If there is no pre-existing demand for the compressor to operate, the auxiliary pool water heater (remote by others) will be engaged by closing the output signal. On a dehumidification call with room temperature in the deadband (neutral reheat mode) the compressor excess heat is rejected in parallel between the hot gas reheat coil and the outdoor condenser. The supply air temperature rise is approximately same temperature as the return air providing a stable room temperature and humidity level.
f. On a pool enclosure temperature drop the controller provides a signal to energize the auxiliary space-heating coil. The controller has a built-in heating/cooling dead band to prevent cycling. Dehumidification and water heating operate normally during this mode. Auxiliary space heating is provided by the hot water heating coil.
g. On a rise in space temperature above set point the controller shall start the compressor diverting all hot gas to the remote air cooled condenser for 100% heat rejection. In a multiple compressor system, each compressor stage is turned on based on a proprietary predictive algorithm. The system shall have an integral receiver to enable year round cooling operation on demand.
h. The unit shall be supplied with water temperature sensors to alert low or loss of water flow. Unit continues to operate to provide room temperature and humidity control without pool water flow and a service message on the controller will signal fault.

Normal operation and status resumes on water flow.

i. If supply air temperature falls below freezestat setpoint or optional freezestat sensor indicates a freezestat condition, all exhaust fans are stopped and all outdoor air dampers are fully closed. If freezestat alarm is tripped the alarm has to be manually cleared by operator.

j. The dehumidifier shall be equipped with an input for use as a firestat interlock. When contact opens the blower shall stop immediately and interlocked fresh air damper close.

.15 Factory Performance Testing

a. The unit shall be thoroughly tested under factory test conditions. A copy of the test report shall be available to the engineer upon request.

b. Microprocessor controls shall be factory adjusted and pre-set to the design conditions during testing.

c. The unit shall be accessible for real-time monitoring while in the QC test chamber upon request.

d. Mechanical contractor to coordinate connecting Seresco unit to the internet using a CAT5 Ethernet cable for plug & play functionality and remote facility monitoring and control.

.16 Dehumidifier Selection2

a. Unit shall be Seresco Model NE-002, as supplied by Kilmer Environmental Inc. (905-890-8908) 600 CFM @ 0.5" ESP, 575/3/60 complete with plenum fan, direct drive VFD motor, integral HW heating coil

.17 Performance:

SERESCO Model	NE-002
Moisture removal capacity is	8 lb/hr at 80oF / 50% RH.
Compressor Capacity	25.6 MBH
The blower shall supply	600 cfm at 0.5" ESP.
Fresh air shall be	125 cfm
Net AC Cooling capacity:	15.8 MBH sensible
Unit MCA:	5.0 A, MOP 15 A, 575/3/ 60V
Remote Condenser:	32 MBH 2.0 MCA, MOP 15 A, 575/3/ 60 V
Integral Hot Water Coil	15MBH , 160 EWT

2.16 **RADIANT FLOOR HEATING SYSTEMS**

.1 Piping

a. Material: All radiant floor heating piping shall be nominal high density cross-linked polyethylene as manufactured by REHAU using the peroxide method of cross-linking (PEXa) and with an approved cell classification in accordance with ASTM D 3350. Pipe shall conform with ASTM F 876 and CSA B 137.5, and be certified by CSA or equivalent testing organization.

b. Temperature and Pressure Ratings: Piping shall be rated for 100 PSIG gauge pressure at 180^{o}F temperature (690 kPa @ 82°C) continuous, and 80 PSIG gauge pressure at 200^{o}F temperature (550 kPa @ 93°C) continuous.

c. Oxygen Diffusion Barrier: Piping shall have a co-extruded oxygen diffusion barrier capable of limiting oxygen diffusion through the pipe to less than 0.10 mg/l/day at 104^{o}F (40°C) water temperature, in accordance with DIN 4726.

d. Bend Radius: The minimum bend radius for cold bending of the pipe shall be not less than five (5) times the outside diameter. Bends with a radius less than this shall require the use of a bending template as supplied by the pipe manufacturer, and/or hot air.

e. Install floor heating piping in a counter flow spiral, serpentine and/or spiral design pattern as shown on Klimatrol piping design shop drawings.

f. All floor heating piping shall be fastened using nylon cable binders to a rebar mesh (provided by general contractor) maintaining 32 mm pipe clearance minimum from top and bottom of the concrete slab.

.2 Fittings

a. Fittings shall be manufactured of dezincification-resistant brass and shall be supplied by the piping manufacturer as part of a proven cataloged system. Manifold fittings to be compression nut style with split compression ring.

b. Fittings shall be certified to ASTM F 877, F 2080 and CSA B 137.5 as part of the manufacturer's PEX piping system. Pipe couplings embedded within the thermal mass shall be EVERLOC® cold-expansion compression-sleeve fittings.

.3 Manifolds

a. Material: Distribution manifolds shall be manufactured of machined de-zincified brass and be supplied by the piping manufacturer as a proven cataloged part of the manufacturer's system. Stainless steel and engineered plastic manifolds shall not be acceptable.

b. Balancing Manifolds: Brass balancing manifolds shall be equipped with visual flow gauges, balancing and isolation valves for each circuit, header isolation valves and air vent/fill ports. Manifolds shall be pre-assembled, mounted on metal brackets and ready to install.

c. Each manifold shall be provided with automatic air vents

.4 Controls

a. Each perimeter radiant floor heat zone shall be complete with a 10 kΩ Type II Thermistor slab temperature sensor, as supplied by Klimatrol.

b. Room floor slab sensor shall be read by BAS Contractor. BAS shall operate circulator and 3-way modulating mixing valve to maintain a maximum slab temperature of 90°F at all times when outdoor air temperature is below current room air temperature. Minimum slab temperature shall be 65°F. Mixed supply water shall be maximum of 140°F.

c. BAS shall disable floor warming zone(s) in case of slab overheat or mix supply water temperature overheat. Overheat shall be defined as 2°F above maximum setpoint for a continuous duration of 2 minutes.

d. Valves and Actuators: Circuit balancing valves shall be installed at manifolds and shall allow fluid circulation through the slab heating system. All manifolds shall be equipped with a 2-way electronically operated isolation valve. Valves and actuators shall be supplied by Klimatrol.

.5 Accessories

a. Utilize manufacturer's system installation accessories including: Railfix tube track, nylon cable binders, pipe sleeves, protective sleeving, pipe cutters, pipe uncoilers and other installation tools and aids.pipe ties.

.6 Performance:

a. As per Capacity Schedule Shown on Drawings

PART 3 - EXECUTION.

3.1 HOT WATER SPECIALTIES.

.1 Expansion Tanks

a) Install air cushion tanks of size and model as noted and where located on drawings.

.2 Safety Relief Valves

a) Install safety relief valve where indicated on drawings

b) Install a drain line from the discharge to nearest funnel floor drain or service sink.

.3 Air Purgers

a) Install air purgers at all high points and where indicated on drawings.

3.2 **HEATING BOILERS.**

.1 All boilers shall be installed as per manufacturers recommendations.

.2 After boiler inspection is completed; the manufacturer shall provide the services of a field representative for starting the unit and training the operator. This service shall not exceed two consecutive days.

.3 Obtain all necessary certificates and framed them inside Mechanical room.

3.3 **COOLING TOWER.**

.1 Install fluid cooler as per manufacturer's recommendations and as detailed on drawings.

.2 Refer to Control and Instrumentation, Section 15900 for operation.

.3 Check valving and record if full condenser water flow is passing through cooler(s). Check air vents in header(s) to be sure all air has been purged.

.4 Record that all the winterizing provisions are operational, such as sump heater, heat tape and insulation on water make-up, sump pump casing and sump pump piping per specification.

.5 Check and record correct operating sequence of two position positive closure damper motors.

.6 Check out and record if pump and fan motor(s) are operational.

.7 Check if sump drain valve is closed.

.8 Check and record that sump has been filled. Check float level and valve operation.

3.4 **WATER COOLED SCREW CHILLER.**

.1 Install units on a flat surface level within 1/8 inch and of sufficient strength to support concentrated loading with isolation spring assemblies under the units.

.2 Provide components furnished as per manufacturer’s literature.

.3 Provide all water piping so centrifugal units and water circuits are serviceable, without having to dismantle excessive lengths of pipe.

.4 Provide valves in water piping upstream and downstream of the evaporator and condenser water boxes for isolating the shells for maintenance and to balance and trim the system.

.5 Provide drain valves and vent cocks to each water box.

.6 Provide strainers ahead of all pumps and automatic modulating valves.

.7 Provide all necessary auxiliary water piping for oil cooler in accordance with the manufacturer's recommendations.

.8 Provide pressure relief piping from relief valve to outside in accordance with manufacturer=s instructions and CSA-B52-1992.

.9 Provide certified wiring schematics to the electrical division for the chiller, associated equipment and controls.

.10 Provide all necessary control wiring as recommended by the manufacturer.

.11 Provide vapour proof flow switches in both chilled and condenser water piping interlocked to the control panel.

3.5 **CHEMICAL TREATMENT.**

.1 Products and Materials - Chemicals and chemical feed equipment shall be as supplied by Water Management Consultants Inc. (WMC) – Authorized Distributor of GE Water & Process Technologies.

.2 Closed Recirculating Systems

a. Equipment Installation
Install the feeder and filter in a by-pass arrangement across the headers of the primary pump set. Isolation venting and drain valves to be installed as per installation drawings and on-site instruction by water treatment representative. Install corrosion coupons in two :"tee" fittings on upstream side of feeder.

b. System Cleaning and Flushing

Prior to cleaning, contractor to verify that the systems have been hydrostatically tested. Thoroughly flush the closed system with raw water to remove loose mill scale and debris. Remove and clean all strainers and flush all low points before chemical cleaner is added to system. Particulate matter that remains in the system at this point is the responsibility of the mechanical Contractor and may require a larger hose connection if system is not dropping quickly enough.

- Add WMC/GE Ferroquest FQ7103 Cleaner for removal of oil, mill scale and iron oxide. Recirculate for a minimum of 72 hours. After recirculation, rinse for 24 hours and continue flushing until the water coming ou to drain is clean and clear.
- Acceptability of water condition to be determined through testing and visual examination of water samples by the water treatment supplier. Copies of test reports to be submitted by the water treatment supplier to the Mechanical Contractor for verification to the Engineer and/or Architect as required.
- Add WMC/GE Corrshield NT4201 corrosion inhibitor to achieve prescribed maintenance levels.
- Insert cartridges in filter.

.3 Open Open Re-Circulating System

a. <u>Equipment Installation</u>
Install packaged automatic control system and chemical containers in allocated areas. Chemical injection point and bleed-off drain to be fitted as per drawings and on-site instruction by water treatment representative. Mount the system in an accessible location. Install make-up water meter on the tower make-up line. Electrical connections as required are the responsibility of the Mechanical Contractor.

b. <u>System Flushing</u>

Thoroughly flush the tower/condenser loop with raw water to remove loose mill scale and debris. Remove and clean all strainers and flush all low points before system is put into service.

.4 Maintenance

a. Maintain inhibitor levels and other water quality control ranges as they apply, from the time the system is brought on-line after flushing and cleaning. The chemical supply allotment provided by the Water Treatment Supplier is effective from the time the system is brought on-line.

b. The water Treatment supplier shall provide all necessary supervision during installation and shall test the systems over the course of the construction period to ensure that proper treatment is being maintained. Reports generated by the Water Treatment Supplier and left on-site are to be compiled for the Engineer's review.

c. The water Treatment Supplier shall provide a service program for the owners. This program shall include training of operating personnel, laboratory testing as required, technical assistance and routine water analysis and recommendations.

d. Frequency of service calls by the Water Treatment Supplier to be sufficient to meet system stability requirements. This requirement to be nullified in the event that a different supplier is contracted by the Owner after turnover of the facility.

.5 Certification

The Mechanical Contractor shall supply the Engineer with certified documentation that the systems have been properly equipped, chemically cleaned and are maintaining sufficient levels of scale/corrosion inhibitor.

3.6 **REFRIGERANT MONITOR SYSTEM.**

.1 The ventilation system will be hooked up directly to the refrigerant monitor.

.2 Provide complete commissioning service by the manufacturer's authorized representative.

3.7 **DEHUMIDIFIER**

.1 Product Delivery, Acceptance, Storage and Handling

a. Perform a thorough physical inspection of the unit upon delivery from the shipment carrier.
b. Identify and report any physical damage immediately to manufacturer.
c. If unit is to be stored prior to installation store in a clean, dry place. Protect from weather, dirt, fumes, water, construction, and physical damage.
d. Handle unit carefully during installation to prevent damage, breaking, denting and scoring.
e. Damaged units or damaged components shall not be installed. Contact manufacturer for RMA instructions.
f. Comply with manufacturer's rigging and installation instructions for unloading the unit and moving it to the final location.

.2 Installation

a. Installation and execution of all work is to be in accordance with the mechanical

drawings, specifications and the manufacturer's printed instructions by workmen experienced in this type of work.

b. Units shall not be run at any time during any construction phase. A request can be made but Manufacturer reserves the right to refuse the request. Otherwise, units standard two (2) year and all extended warranties void.

c. Installing contractor shall review the site to establish the scope of work and installation requirements. Contact Kilmer Environmental (905 890-8908) the equipment supplier as needed. Upon completion the mechanical system and all accessories and controls shall be balanced and commissioned.

d. Locate unit to provide adequate service clearances all sides and to ensure adequate access to remove major components should future service deem necessary. Where installing piping adjacent to units, allow space to remove access panels and for service and maintenance.

e. Hang or mount unit on housekeeping pad/supports at suitable height to facilitate connection to unit drain.

f. Mount unit on suitable isolators at corners and midpoints for sufficient support.

g. Field pipe unit drain in rigid plastic or copper to nearest floor drain and heat trace where exposed to freeze.

h. Pipe pool circuits of unit in CPVC complete with balancing and isolation valves.

i. On outdoor units or locations subject to freeze slope piping to positively drain water back into the building in the event of loss of water flow, pump operation or power failure etc.

j. Duct connections: Drawings indicate the general arrangements of the ducts.
- Connect units to ducts with flexible duct connectors in compliance with requirements.
- Insulate ducts and install manual balancing and motorized shutoff damper(s) as required.
- Install turning vanes to ensure uniform air flow through filters and coils, maximize fan static regain and to minimize static pressure losses.

k. Mount and wire all controls and accessories shipped loose with the unit. This contractor shall provide for the supply and installation by appropriate trades all additional remote mounted equipment, accessories and hardware not supplied with the unit to achieve a complete operational system according to the specifications.

l. Provide all interlock wiring between unit and controls and with remote equipment including condensers, pumps, fans, dampers valves, controls etc as applicable to the completion of the entire system.

m. Mount the Seresco remote controller in the pool area, facility maintenance office or where indicated by owner and wire to the unit control panel with RJ-11 4 wire (telephone) shielded cable.

n. Wire unit interface with the building BACS system where applicable.

o. Wire CAT5 cable from unit microprocessor to nearest router for remote monitoring internet connection

p. Electrical connections: Comply with requirements for power wiring, switches and motor controls in electrical sections. Provide primary power to unit, condensers, heaters, pumps and all accessories as applicable complete with non-fused disconnects in accordance with equipment nameplate ratings.

q. Installer shall provide the services of a qualified licensed refrigeration mechanic to install, pipe and charge the outdoor condenser in accordance with specifications, TSSA and/or applicable jurisdiction and code requirements. Installation of the condenser must be performed in strict accordance with the installation manual and data on the unit nameplate. The refrigerant lineset must not exceed the lengths and dimensions on the unit nameplate as the refrigerant receiver is sized accordingly.

r. Contractor shall clean unit and clean or replace all filters prior to commissioning.

s. Contractor shall clean and flush all water lines, balance air and water flows to specified and provide a copy of balancing report to supplier prior to commissioning.

t. Contractor shall not use the dehumidifier to heat the space during construction or unit

warranties will be voided.

u. Equipment supplier shall provide the services of a factory trained technician to assist the contractor in commissioning the system and to demonstrate operation and maintenance to the owner representative. The agency responsible for start-up should work in accordance with the specifications and in accordance with the Seresco's instructions and only by workers experienced in this type of work. Provide a copy of the start-up report and factory warranty registration to the owner.

.3 Start Up

a. Detailed instructions for start-up as provided by the manufacturer must be followed.
b. Installing contractor must contact the manufacturer prior to start-up to confirm start-up procedures.
c. Equipment supplier shall provide commissioning, owner demonstration and training as part of the equipment sales contract, by a qualified, factory service mechanic technician
d. All units shall be thoroughly cleaned by the installing contractor in accordance with the manufacturer's instructions prior to being placed into service.
e. Start-up service shall be provided by a factory certified technician and/or factory WEB Assisted and must include complete testing of all controls and unit operation. The agency responsible for start-up shall record the refrigeration pressures and electrical operating data. Copies of this data are to be supplied to the owner and manufacturer.

.4 Factory Test

a. Refrigeration and electrical system operation and specification conformance shall be verified by factory test prior to shipment.

.5 Warranty

a. The unit shall be protected by a two year limited warranty covering parts and a limited 60 day warranty covering labor. The compressor shall be protected by an additional three year warranty covering parts.
b. Remote internet access and control must be initiated and confirmed by the factory prior to start-up for extended 1 year factory labour warranty to be in effect.

3.8 RADIANT FLOOR HEATING SYSTEM

.1 Preparation

a. Concrete Slab on Grade: Subgrade should be compacted, flat and smooth to prevent damage to pipe or insulation. Approved vapor barrier material should be installed. Insulation should be installed vertically along all exterior walls or footings to which the edge of the slab will meet against. Horizontal insulation should be installed flat against the vapor barrier under where the slab will be poured. Rigid foam board insulation panels should be taped together at the seams. Reinforcing wire mesh or rebar, if required by structural design, must be flat and level, with all sharp ends pointing down. Finished grade of the thermal mass must be a minimum of 3/4" (19 mm) above the top of PEX heating pipes.

b. Install floor heating piping in a combination spiral / counter flow spiral design pattern as shown on the KLIMATROL piping design shop drawings.

c. All floor heating piping shall be fastened using nylon cable binders to a middle rebar mesh (provided by general contractor) maintaining 800 mm pipe clearance from top and bottom of the concrete slab and keeping the pipe centered in the concrete slab.

d. Pre-cast Concrete Subfloor: Subfloor must be clean and free from all construction debris, which could potentially damage the pipe. Replace any areas that appear weak. If called for by design, approved vapor barrier material should be installed and insulation should be installed vertically along all exterior walls or footings to which the edge of the slab will meet against, as well as flat against the vapor barrier under where the slab will be poured. Rigid foam board insulation panels should be taped together at the seams. Finished grade of the thermal mass overpour must be a minimum of 3/4" (19 mm) above the top of PEX heating pipes.

e. Preparation of Wall Cavity for Manifold Installation: Review drawings and/or design to determine proper locations for manifolds. Check cabinet specifications to determine the width of the wall cabinet (if required) and required wall opening dimensions. Mount the manifold cabinet allowing space for the screed to fill up the front of the pipe opening. If a cabinet is not used, prepare a suitable cavity for the manifold, with a secure mounting plate that will place the manifold at least 30 inches (75 cm) above floor level. If a manifold is to be installed on a wall that will not be constructed until after the heating pipe installation, then a temporary support must be built to secure the manifold in the location that it will stay after the wall is constructed. Manifold must be installed in an area that will allow easy access for supply/return piping as well as future access for maintenance.

.2 Installation

a. Install in accordance with manufacturer's published installation manual and/or published guidelines.

b. Mount manifolds in the locations previously prepared or in previously installed cabinets, if used. Manifolds should be mounted as level as possible.

c. Route piping in orderly manner, according to layout and spacing shown in approved submittal drawings. All notes on drawings shall be followed.

d. At connections and fittings, use a plastic pipe cutter to ensure square and clean cuts, and join pipes immediately or cap ends of pipe to seal from contaminants. Where fittings are installed within the thermal mass, they shall be wrapped in chloride-free tape or sealed within a heat-shrink material approved by the manufacturer.

e. Pipe should be dispensed using a suitable uncoiling device. Remove all twists prior to securing pipe. Pipe must lie flat on an even plane. Finished grade of a thermal mass must be a minimum of 3/4" (19 mm) above the top of PEX heating pipes. Fasten piping at no more than 3 feet (90 cm) intervals, being careful not to twist the pipe. In thin concrete slabs, it may be necessary to secure piping every 2 feet (60 cm). Use only fasteners supplied or approved by the manufacturer of the PEX pipe.

f. Piping that must pass through expansion joints shall be covered in protective polyethylene convoluted sleeving (flexible conduit) extending 15 inches (38 cm) on each side of the joint. Sleeving must be secured on pipe to prevent movement during installation of thermal mass.

g. Where piping exits the thermal mass, a protective conduit shall be placed around the pipe, with the conduit extending a minimum of 6 inches (15 cm) into the floor and exiting by a minimum of 6 inches. For penetrations at manifolds, use rigid PVC bend guides secured in place to prevent movement.

h. At the time of installation of each circuit of pipe, connect the pipe to the correct manifold outlet and record pipe length for balancing. If manifold is not installed, cap the end of the pipe and label the pipe's circuit numbers along with S for supply and R for return. Connect pipes to manifold as soon as possible and record circuit lengths. All circuits shall be labeled to indicate circuit length and serviced area.

i. The following precautions shall be taken in areas intended for carpet:

- Notify carpet installer that radiant heating pipes have been installed.
- Keep pipes 6 inches (15 cm) from all wall baseplates.
- Install metal guards where pipe will pass through wall baseplates and where

carpet tack strips will be installed.

j. The following precautions shall be taken in areas intended for hardwood flooring:

Ensure that nailing areas for hardwood flooring (if nailing is required) are clearly marked and known to hardwood installers.

k. The heating system should not be put into operation until the poured concrete thermal mass has cured a minimum of 28 days, unless otherwise specified and approved by thermal mass supplier. If it is necessary to operate the heating system to prevent freezing, a maximum flow temperature of 72^{o}F (22°C) must not be exceeded while the thermal mass is curing. After curing, gradually increase the flow temperature by no more than 10^{o}F (6°C) each day until system reaches the required operating temperature.

f. Contractor shall be responsible for provision of

- Wire mesh or rebar to secure tubing and any insulations to be provided by the general contractor
- Labour to install Radiant Floor Heating system
- Water, glycol and any chemical solutions.
- Field coordination of the pressure test equipment. (It is recommended to use the REHAU hydraulic pressure test unit available through Klimatrol to conduct pressure tests.)
- Supervision of concrete pours to instruct concrete installers on maintenance of pipe integrity and position of pipe in slab during concrete installation.
- Installation of control valves, pumps, supply and return piping, all valves and fittings.
- Electrical control interconnection and testing.

.3 Field Quality Control

a. Filling, Testing & Balancing: Tests of hydronic heating systems shall comply with local codes, and, where required, shall be witnessed by the building official. (Reference BOCA, ICBO, SBCCI or the acceptable code body for the jurisdiction).

b. Pressure gauges used must show pressure increments of 1 PSIG and should be located at or near the lowest points in the distribution system.

c. Air Test: Charge the completed, yet unconcealed pipes with air. Do not exceed 150 PSIG. Use liquid gas detector or soap solution to check for leakage at manifold connections.

d. Perform a preliminary pressure test pressurizing the system to the greater of 1.5 times the maximum operating pressure or 100 psi for 30 minutes. As the piping expands, restore pressure, first at 10 minutes into the test and again at 20 minutes. At the end of the 30 minute preliminary test, pressure must not fall by more than 5 PSIG from the maximum, and there shall be no leakage.

e. After performing the preliminary test, perform the main pressure test immediately. The main pressure test shall last 2 hours. The test pressure should be restored and must not fall more than 3 PSIG after 2 hours. No leakage should be detected.

f. Pressure shall be maintained and monitored during installation of the thermal mass. If any leak is detected during installation of thermal mass, the leak must be found immediately and the area cleared for repair using manufacturer approved repair coupling. Retest before covering repair.

g. Water Test: Purge all air from pipes. Charge the completed, yet unconcealed pipes with water. Take necessary precautions to prevent water from freezing. Check the system for leaks, especially at all pipe joints.

h. Perform the same procedures as used in the Air Test (3.3.2.1 – 3.3.2.3.).

PART 1 - GENERAL

1.1 GENERAL PROVISIONS.

.1 Conform to the General Provisions of Section 15010.

.2 Provide work under this Section as shown or specified and in accordance with the requirements of the Contract documents.

1.2 QUALITY ASSURANCE.

.1 Conform to local and district by-laws, regulations and published engineering standards.

.2 Conform to Ontario Building Code, Reg. 925 under the Building Code Act.

.3 Conform to SMACNA Duct Construction Standards (Latest Edition).

.4 Conform to ASHRAE Duct Construction Recommendations (Latest Edition).

1.3 RELATED WORK UNDER OTHER SECTION.

- General Mechanical Conditions	Section 15010
- Basic Materials & Methods	Section 15050
- Insulation	Section 15180
- Electrical	Division 16

1.4 SUBMITTALS

.1 Submit shop drawings in accordance with Section 15010 paragraph 2.2 for all equipment.

PART 2 - PRODUCTS.

2.1 DUCTWORK.

.1 General

a) Materials: Lock forming quality steel with Z 275 designation. Zinc coating to ASTM A525M.

b) Low Pressure Ductwork: for ductwork with static pressure up to 2".

c) Gauge and construction of ducts and fittings shall be in accordance to SMACNA and/or ASHRAE standard.

.2 Flexible Duct

a) Acoustic flexible duct shall be Flexmater T-L-A, factory fabricated of all-metal construction consisting of bonded two-ply laminate mechanically corrugated and 25% minimum perforation. Flexible duct shall be of semi-rigid construction capable of being easily formed into elbows or offsets without subsequent sagging. Flexible duct shall be covered with a 25 mm thick acoustic insulation covered with a vinyl sleeve.

b) The flexible duct shall be rated for a maximum working velocity of 2500 FPM at 150 mm static pressure (low pressure) ductwork, and be labelled by Underwriters' Laboratories of Canada under their ULC-181 Standards as a Class I air duct and shall comply with NFPA Standard No. 90A

c) The duct shall be Atlas A1-U-Flex type P>I> (pre-insulated) as manufactured by Trans-Continental Equipment Limited, or approved equal.

d) Connection to branch ducts shall be made with Ruskin spin-in collars. Joints shall be sealed and duct secured with metal screw-type bands. Flexible ductwork shall be supported by suitable strap hangers and 180 mm saddles to prevent sagging. Wire or string will not be accepted. Spin-in collars shall be complete with balancing dampers.

e) Maximum length of flexible duct shall be 3 meters and shall be installed with a minimum number of bends. Duct shall be supported at a minimum of 1.2 M.

f) Flexible ductwork sizes shall match diffusers neck sizes.

.3 Rectangular Duct and Fittings

a) Make duct work exposed to weather of soldered construction, prime painted and finished in two coats of alkyd paint in approved colours unless protected or noted.

b) Seal and weatherproof ducts passing through roof. Solder all joints and seams. Degrease and prime paint any ferrous counter flashings.

c) Form ducts with gauge markings on exterior of ductwork visible from floor.

d) Make joints suitably air tight with traps in direction of air flow. Whenever possible, sizes of ducts shall conform to those indicated. Where building conditions require shape be modified, ducts must have same cross-sectional area indicated and width of duct shall not exceed four times the size of depth except with special approval. Ductwork shall be in accordance with SMACNA/ ASHRAE Guide of latest publication.

e) Construct ducts up to 600 mm with reinforced ribs, formed by pocket slip spaced not more than 2.4 m apart. Make ducts 600 mm and over in either dimension with reinforcing rib formed by pocket slip spaced not more than 4 feet apart. Provide supplemental stiffening, etc. to prevent drumming and make a structurally sound assembly. Cross-break all duct faces except those to which rigid board type insulation is to be applied.

2.2 **GRILLES, CEILING DIFFUSERS.**

.1 Shall be E H Price, Krueger, Titus, as noted on the schedules on the drawings.

2.3 **LOUVRES.**

.1 All exterior louvres shall be aluminum, all welded, weatherproof and complete with aluminum screen. Colour to be determined by the Architect at a later date.

.2 Provide opposed blade dampers to all supply and return grilles.

.3 Co-ordinate with architectural/interior design drawing, regarding mounting details.

.4 Corridor fresh air grille finish to be determined by the architect at a later date.

.5 Provide sample grille and diffuser as site office for approval.

2.4 **FLEXIBLE CONNECTIONS.**

.1 Provide flexible connections of 24 oz/ square yard Durolon coated glass fabric between all equipment and duct work and where shown. Provide suitable sheet metal rain guard for exterior fabric connections secured to fan only. Minimum length is 6" .

2.5 **MANUAL DAMPERS.**

.1 Provide splitter damper in each supply riser take-off. Provide manual balancing damper in each supply or exhaust takeoff set as close as possible to trunk duct. Make turning vanes, dampers, deflectors, splitters of same material and thickness as for equal size ductwork with formed edges, cross-broken and stiffened. Fit balancing dampers with lockable quadrant operator Duro Dyne #KS-195L. Fit splitter dampers with Duro Dyne #SPR24/SRP40 rod-operators spaced at maximum 24" centres. Splitters shall be full depth of branch duct and 1-1/2 times branch width.

2.6 **FIRE DAMPERS.**

.1 Constructed to ULC Standard ULC-S112-M90 and shall be ULC listed and label-led for 1 1/2 hour fire rating.

.2 Fire dampers shall be galvanized steel channel frame curtain type galvanized steel interlocking blades, minimum 22 gauges galvanized steel enclosure, and 160 deg.F. fusible link standard.

.3 Fire dampers for horizontal installation in vertical ductwork shall be operated by a stainless steel closure spring and latch.

.4 Fire damper configurations shall be low resistance type B with blades located outside of the air stream for rectangular ductwork, and type C for round or oval ductwork.

.5 Ceiling fire dampers shall be ULC labeled, for fire-rated membrane type ceilings, galvanized steel construction with heat retardant blanket (non-asbestos) with standard 160 deg.F. fusible link, equal to Controlled Air Manufacturing Model CFS or CFSR, Air Balance of Canada, Kerr Hunt or Penn.

2.7 **GAS VENTS.**

.1 Provide gas vents size and location as indicated on drawings and according to manufacturer’s recommended material and installation method including all necessary support plate, firestop spacers, weathercaps, etc.

.2 Refer to Architectural drawings for roof, curb, and flashing details.

PART 3 - EXECUTION.

3.1 **DUCTWORK.**

.1 Support duct assembles and components from building structure with 25 mm x #18 gauge galvanized steel 'Z' band hanger secured under ducts. Support ducts over 900 mm size with /100 mm steel rods and 32mm x 32 mm x 6 mm angle iron up to 1800 mm and 50mm x 38 mm x 9 mm rods for larger sizes. Space hangers at not over 1.8 m centres.

.2 Make radius of turns at least one duct width. Where space prevents such radius, make turns square and fit with turning vanes of double faced hollow type Duro Dyne vane-rails secured with sheet metal screws.

.3 Seal all duct joints during construction with Duro Dyne S-3 standard duct sealer. Apply to faces of joints before cleats are installed.

.4 Provide access doors of suitable size (min. 300 mm x 400 mm), for access to installed equipment in ducts and where necessary for access to balancing and Fire Dampers. Make doors of 22 U.S. gauge galvanized steel hinged to 22 gauges galvanized to give tight closure on fire resistant gaskets. Provide access in ceilings where necessary for splitter and balancing dampers.

.5 Provide extension collars for outlets, sound absorbers, air guide vanes and other special features as indicated or required including connections to equipment provided by Owner or other Sections. Transition ducts at not more than 30 degree slope to full size of each grille, register, louvre, coil or equipment.

.6 Paint inside of duct connections behind each grille and register with two coats of black non-reflective paint to visually conceal duct interior to approval.

.7 Where any construction impediment or requirement renders the dimensions as shown impossible, the ductwork is to be altered so as to give an effective sectional area equal to that originally shown, without exceeding an aspect ratio of 4:1. Any changes so made shall be done at no additional cost.

.8 Where any construction impediment or requirement render ducting off sets, risers, transition or alteration for piping, conduits, etc., the changes to be made shall be done at no additional costs.

.9 At floor line and at other points where ducts join louvres, concrete or masonry construction or where ducts pass through floors, rivet ducts on approximately 6" centres to 38 mm x 38 mm x 3 mm galvanized steel angles secured with expansion shields and bolts on approximately 300 mm centres and caulk air and water tight.

.10 Install ductwork to clear structural members and any fire-proofing. Locate ducts to permit their proper insulation where required. Do not remove or damage structural fireproofing. Leave space to permit insulation and fireproofing to be Section 15800 inspected and repaired.

.11 Seal all ducts entering ceiling plenums air and noise tight with fibreglass packed snug around all four sides and sealed with approved incombustible caulking/sealing compound to approval. If openings are larger than 1", cement grout opening and then seal to approval. Report all other openings left unsealed in writing.

.12 Supply and install where shown manual quadrant locking dampers for system balancing.

.13 Ducts passing through roof shall have suitable approved minimum 12" high curb built and flashed over by another Section. Counter flashing of ducts by this Section, of same material and finish as flashing. See 15010, Flashings.

.14 Inside paint and seal all fresh air intakes, all fresh air and mixed air ducts to supply fans, A.C. and supply Air Units; and relief or exhaust ducts from motorized or gravity backdraft dampers to exterior outlets with two coats of C.I.L. #979 Houseguard or other approved anti-corrosion paint.

.15 Seal uninsulated duct work exterior to building with Flintkote #110-14 or equal applied to joints. Apply a coating of #110-14 over entire surface. Apply layer of #10 x 20 weave Glasfab followed by second coat of #110-14 over entire surface. Apply #110-14 at not less than 3 gallons per 100 sq. feet of area. Apply at least two coats of alkyd paint in approved colour overall.

.16 After final adjustments are made for air handling systems, lock each control device in position and visually indicate required setting. For splitter and balancing dampers, provide additional lock screw or bolt to approval.

3.3 **GRILLES, REGISTERS AND DIFFUSERS.**

.1 All grilles, registers and diffusers shall have finish as shown on drawings. On all grilles and registers in plastered ceilings or walls, supply for installation plaster rings or plaster frames sized to suit the grille or register if so required by the unit. Supply and install all grilles, register, and diffusers of sizes and types shown or indicated on the Drawings. Before preparing shop drawing and sample submission, coordinate with Architectural drawings regarding ceiling/border type.

.2 Co-operations shall be exercised so that registers and diffusers do not conflict with structural steel, lights, tile and grids, etc. It is the responsibility of this Contractor to bring to the Architect's attention any such conflict of equipment prior to the installation of any ductwork.

.3 Supply and install insulated plenum for all eggcrate type grilles.

3.4 **FANS.**

.1 Supply, install and connect supply, exhaust and return air fans of capacities and sizes as specified in the schedule and at the location indicated on the Drawings.

.2 All connections to fans shall be made utilizing canvas connections as specified under Section 15800.

.3 All fan systems are to be equipped with all accessories indicated in schedule.

3.5 **FIRE DAMPERS.**

.1 Supply and install U.L.C. listed and approved fire dampers in all ducts at the location where ducts pass through walls of a hazardous area, fire separation wall or ceiling space where the ceiling is required to provide a fire rated separation, or any other area or location required by Ontario Building Code, or codes and regulations having jurisdiction on this work.

.2 Dampers shall be held open by a 160 deg. F. fusible link conforming the ULC-S505 1974, revision 1 May 1975, and damper or flap shall lock in position on closure. Access panels and doors of suitable size shall be provided in ductwork and ceilings to allow resetting of the dampers. Retaining clips to be on access door side of damper or flap.

.3 Installation shall be in strict accordance with manufacturer's recommendations and NFPA-90A and any applicable code or regulation.

3.6 **BALANCING.**

.1 The Mechanical Contractor shall hire a certified Balancing Contractor to make the system fully operational. Also to assist commissioning agent per requirements set in section 15995. Submit (3) copies of test and balancing report for engineer’s approval.

PART 1 - GENERAL

1.1 DESCRIPTION

.1 The purpose of this section is to specify Division 15 responsibilities in the energy systems commissioning process, specifically for LEED Certification under LEED Canada NC-1.0.

.2 Commissioning. Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. This is achieved by beginning in the design phase and documenting design intent and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.

Commissioning during the construction phase is intended to achieve the following specific objectives according to the Contract Documents:

1) Verify that applicable equipment and systems are installed according to the manufacturer's recommendations and to industry accepted minimum standards and that they receive adequate operational checkout by installing contractors.
2) Verify and document proper performance of equipment and systems.
3) Verify that O&M documentation left on site is complete.
4) Verify that the Owner's operating personnel are adequately trained.

The responsibilities of the Division 15 contractor(s) in the commissioning process is described in 1.2 of this Section.

.3 The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

.4 Abbreviations. The following are common abbreviations used in the *Specifications* and in the *Commissioning Plan.*

A/E-	Architect and design engineers	FT-	Functional performance test
CA-	Commissioning authority	GC-	General contractor (prime)
CC-	Controls contractor	MC-	Mechanical contractor
CM-	Construction Manager (the owner's representative)	PC-	Prefunctional checklist
Cx-	Commissioning	Subs-	Subcontractors to General
Cx Plan-	Commissioning Plan document	TAB-	Test and balance contractor
EC-	Electrical contractor		

.5 The mechanical systems to be commissioned are listed in Table 1 below:

Table 1 – Energy Systems to be Commissioned (Division 15)

Equipment and System	Scope
Chillers	All
Pumps	All
Cooling tower/Dry cooler	All
Pool heater	All
Boilers (DHW and heating)	All
Variable frequency drives	All
Air handlers including heat recovery systems	All
Garage fans/CO systems	All
In-Suite Fan Coils	281 sample suites
Packaged air conditioning units	All
Unit heaters	All
Testing, Adjusting and Balancing work	All central and common area systems
HVAC control system	All

.6 Commissioning requires the participation of Division 15 to ensure that all systems are operating in a manner consistent with the Contract Documents. Division 15 shall be familiar with the commissioning plan to be issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 **RESPONSIBILITIES**

.1 Mechanical, Controls and TAB Contractors. The commissioning responsibilities applicable to each of the mechanical, controls and TAB contractors of Division 15 are as follows (all references apply to commissioned equipment only):

Construction and Acceptance Phases

a) Include the cost of commissioning in the contract price.
b) In each purchase order or subcontract written, include requirements for submittal data, commissioning documentation, O&M data and training.
c) Attend a commissioning scoping meeting and other meetings necessary to facilitate the Cx process.
d) Contractors shall provide the CA with normal cut sheets and shop drawing submittals of commissioned equipment.
e) Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of start-up and functional testing procedures.
    a. Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation, start-up and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

b. The Commissioning Agent may request further documentation necessary for the commissioning process.
c. This data request may be made prior to normal submittals.

f) Provide a copy of the O&M manuals and submittals of commissioned equipment, through normal channels, to the CA for review and approval.
g) Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
h) Provide limited assistance to the CA in preparing the specific functional performance test procedures as specified in Section 15997. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
i) Develop a full start-up and initial checkout plan using manufacturer's start-up procedures and the prefunctional checklists from the CA for all commissioned equipment. Submit to CA for review and approval prior to startup.
j) During the startup and initial checkout process, execute the mechanical-related portions of the prefunctional checklists for all commissioned equipment.
k) Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
l) Address current A/E punch list items before functional testing. Air and water TAB shall be completed with discrepancies and problems remedied before functional testing of the respective air- or water-related systems.
m) Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
n) Provide skilled technicians to perform functional performance testing under the direction of the CA for specified equipment in Section 15997. Assist the CA in interpreting the monitoring data, as necessary.
o) Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, CM and A/E and retest the equipment.
p) Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
q) During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing).
r) Provide training of the Owner's operating staff using expert qualified personnel, as specified.
s) Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.

Warranty Period

a) Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
b) Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.

.2 Mechanical Contractor and Control Subcontractor. The responsibilities of the HVAC mechanical contractor, during construction and acceptance phases in addition to those listed in (A) are:

a) Provide startup for all HVAC equipment, except for the building automation control system.
b) Assist and cooperate with the TAB contractor and CA by:

a. Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
b. Including cost of sheaves and belts that may be required by TAB.

c. Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
d. Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.

c) Install a P/T plug at each water sensor which is an input point to the control system.
d) List and clearly identify on the as-built drawings the locations of all air-flow stations.
e) Prepare a preliminary schedule for Division 15 pipe and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
f) Notify the CM or CA depending on protocol, when pipe and duct system testing, flushing, cleaning, startup of each piece of equipment and TAB will occur. Be responsible to notify the CM or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed and that the CA has the scheduling information needed to efficiently execute the commissioning process.

g) List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

.3 TAB Contractor. The duties of the TAB contractor, in addition to those listed in (A) are:

a) Six weeks prior to starting TAB, submit to the CM the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician's qualifications for this project.
b) Submit the outline of the TAB plan and approach for each system and component to the CA, CM and the controls contractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system.
c) The submitted plan will include:
a. Certification that the TAB contractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
b. An explanation of the intended use of the building control system. The controls contractor will comment on feasibility of the plan.
c. All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
d. Discussion of what notations and markings will be made on the duct and piping drawings during the process.
e. Final test report forms to be used.
f. Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow straighteners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
g. List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
h. Details of how *total* flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pitot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).
i. The identification and types of measurement instruments to be used and their most recent calibration date.
j. Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.

k. Confirmation that TAB understands the outside air ventilation criteria under all conditions.
l. Details of whether and how minimum outside air cfm will be verified and set, and for what level (total building, zone, etc.).
m. Details of how building static and exhaust fan / relief damper capacity will be checked.
n. Proposed selection points for sound measurements and sound measurement methods.
o. Details of methods for making any specified coil or other system plant capacity measurements.
p. Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
q. Details regarding specified deferred or seasonal TAB work.
r. Details of any specified false loading of systems to complete TAB work.
s. Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
t. Details of any required interstitial cavity differential pressure measurements and calculations.
u. Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
v. Plan for formal progress reports (scope and frequency).
w. Plan for formal deficiency reports (scope, frequency and distribution).

d) A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests to the CA and CM at least twice a week.
e) Communicate in writing to the controls contractor all setpoint and parameter changes made or problems and discrepancies identified during TAB which affect the control system setup and operation.
f) Provide a draft TAB report within two weeks of completion. A copy will be provided to the CA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB or ASHRAE Standard 111.
g) Provide the CA with any requested data, gathered, but not shown on the draft reports.
h) Provide a final TAB report for the CA with details, as in the draft.
i) Conduct functional performance tests and checks on the original TAB as specified for TAB in Section 15997.

1.3 **RELATED WORK**

.1 Section 15010 – General Conditions

PART 2 - PRODUCTS

2.1 TEST EQUIPMENT

.1 Division 15 shall provide all test equipment necessary to fulfill the testing requirements of this Division.

.2 All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical contractor of Division 15 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 15, except for equipment specific to and used by TAB in their commissioning responsibilities. Two-way radios shall be provided by the Division Controller.

.3 Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and left on site, except for stand-alone datalogging equipment that may be used by the CA.

.4 Datalogging equipment and software required to test equipment will be provided by the CA, but shall not become the property of the Owner.

.5 All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the *Specifications.* If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.5°F and a resolution of + or - 0.1°F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

3.1 SUBMITTALS

.1 The CA will provide appropriate contractors with a specific request for the type of submittal documentation the CA requires facilitating the commissioning work. These requests will be integrated into the normal submittal process and protocol of the construction team. At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning authority. All documentation requested by the CA will be included by the Subs in their O&M manual contributions.

.2 The Commissioning authority will review and approve submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning authority will notify the CM or A/E as requested, of items missing or areas that are not in conformance with Contract Documents and which require resubmission.

.3 The CA may request additional design narrative from the A/E and Controls Contractor, depending on the completeness of the design intent documentation and sequences provided with the Specifications.

.4 These submittals to the CA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CA will review and approve them.

3.2 STARTUP

.1 The following procedures apply to all equipment to be commissioned, according to Section 1.7, Systems to be Commissioned. Some systems that are not comprised so much of actual dynamic machinery, e.g., electrical system power quality, may have very simplified PCs and startup.

.2 General. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

.3 Start-up and Initial Checkout Plan. The CA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms. Parties responsible for executing functional performance tests are identified in the testing requirements in Sections 15997.

a) The CA adapts, if necessary, the representative prefunctional checklists and procedures from Section 15998. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.
b) These checklists and tests are provided by the CA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.
c) The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

   The full start-up plan could consist of something as simple as:
   a. The CA's prefunctional checklists.
   b. The manufacturer's standard written start-up procedures copied from the installation manuals with check boxes by each procedure and a signature block added by hand at the end.
   c. The manufacturer's normally used field checkout sheets.

d) The subcontractor submits the full startup plan to the CA for review and approval.
e) The CA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

f) The full start-up procedures and the approval form may be provided to the CM for review and approval, depending on management protocol.

.4 Sensor and Actuator Calibration.

All field-installed temperature, relative humidity, CO, CO_2 and pressure sensors and gages, and all actuators (dampers and valves) on all equipment shall be calibrated using the methods described below. Alternate methods may be used, if approved by the Owner before-hand. All test instruments shall have had a certified calibration within the last 12 months. Sensors installed *in* the unit at the factory with calibration certification provided need not be field calibrated.

All procedures used shall be fully documented on the prefunctional checklists or other suitable forms, clearly referencing the procedures followed and written documentation of initial, intermediate and final results.

Sensor Calibration Methods

All Sensors. Verify that all sensor locations are appropriate and away from causes of erratic operation. Verify that sensors with shielded cable are grounded only at one end. For sensor pairs that are used to determine a temperature or pressure difference, make sure they are reading within 0.2°F of each other for temperature and within a tolerance equal to 2% of the reading, of each other, for pressure.

Sensors Without Transmitters--Standard Application. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, install offset in BAS, calibrate or replace sensor.

Sensors With Transmitters--Standard Application. Disconnect sensor. Connect a signal generator in place of sensor. Connect ammeter in series between transmitter and BAS control panel. Using manufacturer's resistance-temperature data, simulate minimum desired temperature. Adjust transmitter potentiometer zero until 4 mA is read by the ammeter. Repeat for the maximum temperature matching 20 mA to the potentiometer span or maximum and verify at the BAS. Record all values and recalibrate controller as necessary to conform with specified control ramps, reset schedules, proportional relationship, reset relationship and P/I reaction. Reconnect sensor. Make a reading with a calibrated test instrument within 6 inches of the site sensor. Verify that the sensor reading (via the permanent thermostat, gage or building automation system (BAS)) is within the tolerances in the table below of the instrument-measured value. If not, replace sensor and repeat. For pressure sensors, perform a similar process with a suitable signal generator.

Valve and Damper Stroke Setup and Check
EMS Readout. For all valve and damper actuator positions checked, verify the actual position against the BAS readout.
Set pumps or fans to normal operating mode. Command valve or damper closed, visually verify that valve or damper is closed and adjust output zero signal as required. Command valve or damper open, verify position is full open and adjust output signal as required. Command valve or damper to a few intermediate positions. If actual valve or damper position doesn't reasonably correspond, replace actuator or add pilot positioner (for pneumatics).

Closure for heating coil valves (NO): Set heating setpoint 20°F above room temperature. Observe valve open. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set heating setpoint to 20°F below room temperature. Observe the valve close.

Closure for cooling coil valves (NC): Set cooling setpoint 20°F above room temperature. Observe the valve close. Remove control air or power from the valve and verify that the valve stem and actuator position do not change. Restore to normal. Set cooling setpoint to 20°F below room temperature. Observe valve open.

.5 Execution of Prefunctional Checklists and Startup.

a) Four weeks prior to startup, the Subs and vendors schedule startup and checkout with the CM, GC and CA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.
b) The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the CM). In no case will the number of units witnessed be less than four on any one building, nor less than 20% of the total number of identical or very similar units.
c) For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CA shall observe a sampling of the prefunctional and start-up procedures. The sampling procedures are identified in the commissioning plan.
d) The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.
e) Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

.6 Deficiencies, Non-Conformance and Approval in Checklists and Startup.

a) The Subs shall clearly list any outstanding items of the initial start-up and prefunctional procedures that were not completed successfully, at the bottom of the procedures form or on an attached sheet. The procedures form and any outstanding deficiencies are provided to the CA within two days of test completion.
b) The CA reviews the report and submits either a non-compliance report or an approval form to the Sub or CM. The CA shall work with the Subs and vendors to correct and retest deficiencies or uncompleted items. The CA will involve the CM and others as necessary. The installing Subs or vendors shall correct all areas that are deficient or incomplete in the checklists and tests in a timely manner, and shall notify the CA as soon as outstanding items have been corrected and resubmit an updated start-up report and a Statement of Correction on the original non-compliance report. When satisfactorily completed, the CA recommends approval of the execution of the checklists and startup of each system to the CM using a standard form.
c) Items left incomplete, which later cause deficiencies or delays during functional testing may result in backcharges to the responsible party. Refer to Part 3.7 herein for details.

.7 The HVAC mechanical and controls contractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section. Division 15 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.

.8 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all prefunctional checklists as soon as possible.

3.3 FUNCTIONAL PERFORMANCE TESTING

.1 This sub-section applies to all commissioning functional testing for all divisions.

.2 The general list of equipment to be commissioned is found in Paragraph 1.1 (E) of this section. The specific equipment and modes to be tested will be developed and issued to the contractor by the CA. A sample performance test checklist appears in section 15997.

.3 The parties responsible to execute each test are listed with each test in Section 15997.

.4 Objectives and Scope. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.

.5 Development of Test Procedures. Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. Using the testing parameters and requirements in Sections 15997 the CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor responsible to execute a test, shall provide limited assistance to the CA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection. The CA may submit the tests to the A/E for review, if requested.

The CA shall review owner-contracted, factory testing or required owner acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the *Specifications*. Redundancy of testing shall be minimized.

The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.

Representative test formats and examples (not designed for this facility) are found in the appendices to Divisions 15 and 16. The test procedure forms developed by the CA shall include (but not be limited to) the following information:

a) System and equipment or component name(s)
b) Equipment location and ID number
c) Unique test ID number, and reference to unique prefunctional checklist and start-up documentation ID numbers for the piece of equipment
d) Date
e) Project name
f) Participating parties

g) A copy of the specification section describing the test requirements
h) A copy of the specific sequence of operations or other specified parameters being verified
i) Formulas used in any calculations
j) Required pre-test field measurements
k) Instructions for setting up the test.
l) Special cautions, alarm limits, etc.
m) Specific step-by-step procedures to execute the test, in a clear, sequential and repeatable format
n) Acceptance criteria of proper performance with a Yes / No check box to allow for clearly marking whether or not proper performance of each part of the test was achieved.
o) A section for comments
p) Signatures and date block for the CA

.6 Test Methods.

a) Functional performance testing and verification may be achieved by manual testing (persons manipulate the equipment and observe performance) or by monitoring the performance and analyzing the results using the control system's trend log capabilities or by stand-alone dataloggers. Section 15997 specifies which methods shall be used for each test. The CA may substitute specified methods or require an additional method to be executed, other than what was specified, with the approval of the CM. This may require a change order and adjustment in charge to the Owner. The CA will determine which method is most appropriate for tests that do not have a method specified.

b) Simulated Conditions. Simulating conditions (not by an overwritten value) shall be allowed, though timing the testing to experience actual conditions is encouraged wherever practical.

c) Overwritten Values. Overwriting sensor values to simulate a condition, such as overwriting the outside air temperature reading in a control system to be something other than it really is, shall be allowed, but shall be used with caution and avoided when possible. Such testing methods often can only test a part of a system, as the interactions and responses of other systems will be erroneous or not applicable. Simulating a condition is preferable. e.g., for the above case, by heating the outside air sensor with a hair blower rather than overwriting the value or by altering the appropriate setpoint to see the desired response. Before simulating conditions or overwriting values, sensors, transducers and devices shall have been calibrated.

d) Simulated Signals. Using a signal generator which creates a simulated signal to test and calibrate transducers and DDC constants is generally recommended over using the sensor to act as the signal generator via simulated conditions or overwritten values.

e) Altering Setpoints. Rather than overwriting sensor values, and when simulating conditions is difficult, altering setpoints to test a sequence is acceptable. For example, to see the AC compressor lockout work at an outside air temperature below 55F, when the outside air temperature is above 55F, temporarily change the lockout setpoint to be 2F above the current outside air temperature.

f) Indirect Indicators. Relying on indirect indicators for responses or performance shall be allowed only after visually and directly verifying and documenting, over the range of the tested parameters, that the indirect readings through the control system represent actual conditions and responses. Much of this verification is completed during prefunctional testing.

g) Setup. Each function and test shall be performed under conditions that simulate actual conditions as close as is practically possible. The Sub executing the test shall provide all necessary materials, system modifications, etc. to produce the necessary flows, pressures, temperatures, etc. necessary to execute the test according to the specified conditions. At

completion of the test, the Sub shall return all affected building equipment and systems, due to these temporary modifications, to their pre-test condition.

h) Sampling. Multiple identical pieces of equipment will be functionally tested using a sampling strategy. Significant application differences and significant sequence of operation differences in otherwise identical equipment invalidates their common identity. A small size or capacity difference, alone, does not constitute a difference. The specific recommended sampling rates are specified with each type of equipment in Sections 15997 and in Table 1 of this section. It is noted that no sampling by Subs is allowed in prefunctional checklist execution.

An "11% Sampling—10% Failure Rule" is to be used and is defined by the following example.

11% = the percent of the group of identical equipment to be included in each sample.
10% = the percent of the sample that if failing, will require another sample to be tested.

a. Randomly test at least 11% of each group of identical equipment, which constitutes the "first sample."
b. If 10% of the units in the first sample fail the functional performance tests, test another 11% of the group (the second sample).
c. If 10% of the units in the second sample fail, test all remaining units in the whole group.
d. If at any point, frequent failures are occurring and testing is becoming more troubleshooting than verification, the CA may stop the testing and require the responsible Sub to perform and document a checkout of the remaining units, prior to continuing with functionally testing the remaining units.

.7 Coordination and Scheduling. The Subs shall provide sufficient notice to the CA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CA will schedule functional tests through the CM, GC and affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

.8 Test Equipment. Refer to Section 17100, Part 2 for test equipment requirements.

.9 Problem Solving. The CA will recommend solutions to problems found, however the burden of responsibility to solve, correct and retest problems is with the GC, Subs and A/E.

3.4 TESTING DOCUMENTATION, NON-CONFORMANCE AND APPROVALS

.1 Documentation. The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the CM for review and approval and to the Subs for review. The CA will include the filled out forms in the O&M manuals.

.2 Non-Conformance.

a) The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM on a standard non-compliance form.

b) Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.

c) Every effort will be made to expedite the testing process and minimize unnecessary delays, while not compromising the integrity of the procedures. However, the CA will not be pressured into overlooking deficient work or loosening acceptance criteria to satisfy scheduling or cost issues, unless there is an overriding reason to do so at the request of the CM.

d) As tests progress and a deficiency is identified, the CA discusses the issue with the executing contractor.
   a. When there is no dispute on the deficiency and the Sub accepts responsibility to correct it:
      1) The CA documents the deficiency and the Sub's response and intentions and they go on to another test or sequence. After the day's work, the CA submits the non-compliance reports to the CM for signature, if required. A copy is provided to the Sub and CA. The Sub corrects the deficiency, signs the statement of correction at the bottom of the non-compliance form certifying that the equipment is ready to be retested and sends it back to the CA.
      2) The CA reschedules the test and the test is repeated.

   b. If there is a dispute about a deficiency, regarding whether it is a deficiency or who is responsible:
      1) The deficiency shall be documented on the non-compliance form with the Sub's response and a copy given to the CM and to the Sub representative assumed to be responsible.
      2) Resolutions are made at the lowest management level possible. Other parties are brought into the discussions as needed. Final interpretive authority is with the A/E. Final acceptance authority is with the Project Manager.
      3) The CA documents the resolution process.
      4) Once the interpretation and resolution have been decided, the appropriate party corrects the deficiency, signs the statement of correction on the non-compliance form and provides it to the CA. The CA reschedules the test and the test is repeated until satisfactory performance is achieved.

e) Cost of Retesting.

   a. The cost for the *Sub* to retest a prefunctional or functional test, if they are responsible for the deficiency, shall be theirs. If they are not responsible, any cost recovery for retesting costs shall be negotiated with the GC.
   b. For a deficiency identified, not related to any prefunctional checklist or start-up fault, the following shall apply: The CA and CM will direct the retesting of the equipment once at no "charge" to the GC for their time. However, the CA's and CM's time for a second retest will be charged to the GC, who may choose to recover costs from the responsible Sub.
   c. The time for the CA and CM to direct any retesting required because a specific *prefunctional* checklist or start-up test item, reported to have been successfully completed, but determined during functional testing to be faulty, will be backcharged to the GC, who may choose to recover costs from the party responsible for executing the faulty prefunctional test.

d. Refer to the sampling section of Section 17100, Part 3.6 for requirements for testing and retesting identical equipment.

f) The Contractor shall respond in writing to the CA and CM at least as often as commissioning meetings are being scheduled concerning the status of each apparent outstanding discrepancy identified during commissioning. Discussion shall cover explanations of any disagreements and proposals for their resolution.

g) The CA retains the original non-conformance forms until the end of the project.

h) Any required retesting by any contractor shall not be considered a justified reason for a claim of delay or for a time extension by the prime contractor.

.3 Failure Due to Manufacturer Defect. If 10%, or three, whichever is greater, of identical pieces (size alone does not constitute a difference) of equipment fail to perform to the Contract Documents (mechanically or substantively) due to manufacturing defect, not allowing it to meet its submitted performance spec, all identical units may be considered unacceptable by the CM. In such case, the Contractor shall provide the Owner with the following:

a) Within one week of notification from the CM, the Contractor or manufacturer's representative shall examine all other identical units making a record of the findings. The findings shall be provided to the CM within two weeks of the original notice.

b) Within two weeks of the original notification, the Contractor or manufacturer shall provide a signed and dated, written explanation of the problem, cause of failures, etc. and all proposed solutions which shall include full equipment submittals. The proposed solutions shall not significantly exceed the specification requirements of the original installation.

c) The CM will determine whether a replacement of all identical units or a repair is acceptable.

d) Two examples of the proposed solution will be installed by the Contractor and the CM will be allowed to test the installations for up to one week, upon which the CM will decide whether to accept the solution.

e) Upon acceptance, the Contractor and/or manufacturer shall replace or repair all identical items, at their expense and extend the warranty accordingly, if the original equipment warranty had begun. The replacement/repair work shall proceed with reasonable speed beginning within one week from when parts can be obtained.

.4 Approval. The CA notes each satisfactorily demonstrated function on the test form. Formal approval of the functional test is made later after review by the CA and by the CM, if necessary. The CA recommends acceptance of each test to the CM using a standard form. The CM gives final approval on each test using the same form, providing a signed copy to the CA and the Contractor.

3.5 **OPERATION AND MAINTENANCE (O&M) MANUALS**

.1 The following O&M manual requirements do not replace O&M manual documentation requirements elsewhere in these specifications.

.2 Division 15 shall compile and prepare documentation for all equipment and systems covered in Division 15 and deliver this documentation to the CA for inclusion in the general O&M manuals, according to this section, prior to the training of owner personnel.

.3 The CM shall receive a copy of the O&M manuals for review.

.4 Special TAB Documentation Requirements. The TAB will compile and submit the following with other documentation that may be specified elsewhere in the *Specifications.*

a) Final report containing an explanation of the methodology, assumptions, test conditions and the results in a clear format with designations of all uncommon abbreviations and column headings.
b) The TAB shall mark on the drawings where all traverse and other critical measurements were taken and cross reference the location in the TAB report.

.5 Review and Approvals. Review of the commissioning related sections of the O&M manuals shall be made by the A/E and by the CA. Refer to Section 17100, Part 3.8 for details.

3.6. **TRAINING OF OWNER PERSONNEL**

.1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed.

.2 The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.

.3 Mechanical Contractor and Controls Subcontractor. The mechanical contractor shall have the following training responsibilities:

a) Provide the CA with a training plan two weeks before the planned training.

b) Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.

c) Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.

d) During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

e) The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer’s representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment are required. More than one party may be required to execute the training.

f) The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.

g) The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.

h) Training shall include:

a. Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
b. A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
c. Discussion of relevant health and safety issues and concerns.
d. Discussion of warranties and guarantees.
e. Common troubleshooting problems and solutions.
f. Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
g. Discussion of any peculiarities of equipment installation or operation.
h. The format and training agenda in *The HVAC Commissioning Process, ASHRAE Guideline 1-1989R*, 1996 is recommended.
i. Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.

h) Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.

i) The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not *controlled* by the central control system.

k) Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

.4 TAB

The TAB contractor shall have the following training responsibilities:

a) TAB shall meet with facility staff after completion of TAB and instruct them on the following:
a. Go over the final TAB report, explaining the layout and meanings of each data type.
b. Discuss any outstanding deficient items in control, ducting or design that may affect the proper delivery of air or water.
c. Identify and discuss any terminal units, duct runs, diffusers, coils, fans and pumps that are close to or are not meeting their design capacity.
d. Discuss any temporary settings and steps to finalize them for any areas that are not finished.
e. Other salient information that may be useful for facility operations, relative to TAB.

3.7 DEFERRED TESTING

.1 Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the CM. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

.2 Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) specified in Section 15997 shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

PART 1 - GENERAL

1. OVERVIEW

.1 Commissioning is a systematic process of ensuring that all building systems perform interactively according to the design intent and the owner's operational needs. This is achieved by beginning in the design phase and documenting design intent and continuing through construction, acceptance and the warranty period with actual verification of performance. The commissioning process shall encompass and coordinate the traditionally separate functions of system documentation, equipment startup, control system calibration, testing and balancing, performance testing and training.

.2 The commissioning process does not take away from or reduce the responsibility of the system designers or installing contractors to provide a finished and fully functioning product.

.3 These commissioning requirements are LEED-focused and are in addition to, not in place of, any additional commissioning requirements located in the electrical, mechanical, or other specifications.

2. OBJECTIVES

.1 Verify that applicable equipment and systems are installed according to the manufacturer's recommendations.

.2 Verify and document proper performance of equipment and systems.

.3 Verify that O&M documentation left on site is complete.

.4 Verify that the Owner's operating personnel are adequately trained.

.5 The commissioning process shall meet the requirements of LEED Canada-NC Version 1.0 Prerequisite EAp1, Fundamental Building Systems Commissioning. The commissioning shall also meet the requirements as specified in the technical sections of this specification.

3. ABBREVIATIONS

.1 The following are common abbreviations used in the Specifications and in the Commissioning Plan:

BOD: Basis of Design

CA: Commissioning Authority

Cx: Commissioning

Cx Plan: Commissioning Plan

GC: General contractor

OPR: Owner's Project Requirements

TAB: Testing and Balancing Contractor

4. COMMISSIONING TEAM

.1 The members of the commissioning team consist of the following:

(a) Commissioning authority (CA)

(b) General Contractor (GC or Contractor)

(c) The architect and design engineers

(d) Mechanical Contractor (MC), the Electrical Contractor (EC), the TAB representative, the Controls Contractor (CC)

(e) Any other installing subcontractors or suppliers of equipment. If known, the Owner's building or plant operator/engineer is also a member of the commissioning team.

5. SCHEDULING

.1 The CA will work with the CM and GC according to established protocols to schedule the commissioning activities. The CA will provide sufficient notice to the CM and GC for scheduling commissioning activities. The GC will integrate all commissioning activities into the master schedule. All parties will address scheduling problems and make necessary notifications in a timely manner in order to expedite the commissioning process.

.2 The CA will provide the initial schedule of primary commissioning events at the commissioning scoping meeting. The Commissioning Plan—Construction Phase provides a format for this schedule. As construction progresses more detailed schedules are developed by the CA. The Commissioning Plan also provides a format for detailed schedules.

6. COMMISSIONING PROCESS

.1 Commissioning Plan. The commissioning plan provides guidance in the execution of the commissioning process. Just after the initial commissioning scoping meeting the CA will update the plan which is then considered the "final" plan, though it will continue to evolve and expand as the project progresses. The Specifications will take precedence over the Commissioning Plan.

.2 Commissioning during construction begins with a scoping meeting conducted by the CA where the commissioning process is reviewed with the commissioning team members.

.3 Additional meetings will be required throughout construction, scheduled by the CA with necessary parties attending, to plan, scope, coordinate, schedule future activities and resolve problems.

.4 Equipment documentation is submitted to the CA during normal submittals, including detailed start-up procedures.

.5 The CA works with the Subs in developing startup plans and startup documentation formats, including providing the Subs with prefunctional checklists to be completed, during the startup process.

.6 In general, the checkout and performance verification proceeds from simple to complex; from component level to equipment to systems and intersystem levels with prefunctional checklists being completed before functional testing.

.7 The Subs, under their own direction, execute and document the prefunctional checklists and perform startup and initial checkout. The CA documents that the checklists and startup were completed according to the approved plans. This may include the CA witnessing start-up of selected equipment.

.8 The CA develops specific equipment and system functional performance test procedures. The Subs review the procedures.

.9 The procedures are executed by the Subs, under the direction of, and documented by the CA.

.10 Items of non-compliance in material, installation or setup are corrected at the Sub's expense and the system retested.

.11 The CA reviews the O&M documentation for completeness.

.12 The CA reviews, pre-approves and coordinates the training provided by the Subs and verifies that is was completed.

.13 Deferred testing is conducted, as specified or required.

7. SYSTEMS TO BE COMMISSIONED

.1 Fundamental Building Systems Commissioning is limited to those systems and equipment that are central to the Owner's LEED requirements and sustainability goals. LEED commissioning focuses on energy and water-consuming systems. The following systems are included as part of fundamental building systems commissioning requirements.

.2 SYSTEMS INCLUDED IN LEED COMMISSIONING:

(a) HVAC systems & controls

(b) Interior lighting fixtures & controls

(c) Plumbing fixtures & systems

(d) Plumbing infrastructure

(e) Exterior lighting systems & controls

(f) Irrigation

(g) Renewable energy systems

.3 SYSTEMS NOT INCLUDED IN LEED COMMISSIONING`

(a) Envelope integrity

(b) Fire safety systems

(c) Data & Communications

(d) Security Systems

(e) Alternate Fueling Stations

(f) Elevators

(g) Emergency generators & UPS systems

PART 2 - PRODUCTS

1. TEST EQUIPMENT

.1 All standard testing equipment required to perform startup and initial checkout and required functional performance testing shall be provided by the Division contractor for the equipment being tested. For example, the mechanical contractor of Division 15 shall ultimately be responsible for all standard testing equipment for the HVAC system and controls system in Division 15, except for equipment specific to and used by TAB in their commissioning responsibilities.

.2 Special equipment, tools and instruments (only available from vendor, specific to a piece of equipment) required for testing equipment, according to these Contract Documents shall be included in the base bid price to the Contractor and left on site, except for stand-alone datalogging equipment that may be used by the CA.

.3 All testing equipment shall be of sufficient quality and accuracy to test and/or measure system performance with the tolerances specified in the Specifications. If not otherwise noted, the following minimum requirements apply: Temperature sensors and digital thermometers shall have a certified calibration within the past year to accuracy of 0.5◦F and a resolution of + or - 0.1◦F. Pressure sensors shall have an accuracy of + or - 2.0% of the value range being measured (not full range of meter) and have been calibrated within the last year. All equipment shall be calibrated according to the manufacturer's recommended intervals and when dropped or damaged. Calibration tags shall be affixed or certificates readily available.

PART 3 - EXECUTION

1. MEETINGS

.1 Scoping Meeting. The CA will schedule, plan and conduct a commissioning scoping meeting with the entire commissioning team in attendance. Meeting minutes will be distributed to all parties by the CA. Information gathered from this meeting will allow the CA to revise the Commissioning Plan to its "final" version, which will also be distributed to all parties.

.2 Miscellaneous Meetings. Other meetings will be planned and conducted by the CA as construction progresses. These meetings will cover coordination, deficiency resolution

and planning issues with particular Subs. The CA will plan these meetings and will minimize unnecessary time being spent by Subs.

2. REPORTING

.1 The CA will provide regular reports to the Owner and project manager with increasing frequency as construction and commissioning progresses. Standard forms are provided and referenced in the Commissioning Plan.

.2 The CA will regularly communicate with all members of the commissioning team, keeping them apprised of commissioning progress and scheduling changes through memos, progress reports, etc.

.3 Testing or review approvals and non-conformance and deficiency reports are made regularly with the review and testing as described in later sections.

.4 A final summary report (about four to six pages, not including backup documentation) by the CA will be provided to the CM or PM, focusing on evaluating commissioning process issues and identifying areas where the process could be improved. All acquired documentation, logs, minutes, reports, deficiency lists, communications, findings, unresolved issues, etc., will be compiled in appendices and provided with the summary report. Prefunctional checklists, functional tests and monitoring reports will not be part of the final report, but will be stored in the Commissioning Record in the O&M manuals.

3. SUBMITTALS

.1 In general, the following submittals are required to be submitted to the CA throughout construction. The specific submittal list appears in the Cx Plan.

(a) Shop drawings, including full sequences of operation and O&M data, to be approved by the CA during the standard engineer's shop drawing review process

(b) Control drawings for all commissioned equipment

(c) Completed installation / pre-verification checklist

(d) Completed functional performance checklist

(e) Air and Water Balancing report

(f) Complete set of O&M manuals, in **PDF** format and hardcopy

(g) Training checklists

(h) **DVDs** indicating videotaped training session for all systems.

.2 At minimum, the request will include the manufacturer and model number, the manufacturer's printed installation and detailed start-up procedures, full sequences of operation, O&M data, performance data, any performance test procedures, control drawings and details of owner contracted tests. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the

Commissioning authority. All documentation requested by the CA will be included by the Subs in their O&M manual contributions.

.3 The Commissioning authority will review and approve submittals related to the commissioned equipment for conformance to the Contract Documents as it relates to the commissioning process, to the functional performance of the equipment and adequacy for developing test procedures. This review is intended primarily to aid in the development of functional testing procedures and only secondarily to verify compliance with equipment specifications. The Commissioning authority will notify the CM, PM or A/E as requested, of items missing or areas that are not in conformance with Contract Documents and which requires resubmission.

.4 These submittals to the CA do not constitute compliance for O&M manual documentation. The O&M manuals are the responsibility of the Contractor, though the CA will review and approve them.

4. START-UP, PREFUNCTIONAL CHECKLISTS AND INITIAL CHECKOUT

.1 General. Prefunctional checklists are important to ensure that the equipment and systems are hooked up and operational. It ensures that functional performance testing (in-depth system checkout) may proceed without unnecessary delays. Each piece of equipment receives full prefunctional checkout. No sampling strategies are used. The prefunctional testing for a given system must be successfully completed prior to formal functional performance testing of equipment or subsystems of the given system.

.2 Start-up and Initial Checkout Plan. The CA shall assist the commissioning team members responsible for startup of any equipment in developing detailed start-up plans for all equipment. The primary role of the CA in this process is to ensure that there is written documentation that each of the manufacturer-recommended procedures have been completed. Parties responsible for prefunctional checklists and startup are identified in the commissioning scoping meeting and in the checklist forms.

.3 The CA adapts, if necessary, the representative prefunctional checklists and procedures. These checklists indicate required procedures to be executed as part of startup and initial checkout of the systems and the party responsible for their execution.

.4 These checklists and tests are provided by the CA to the Contractor. The Contractor determines which trade is responsible for executing and documenting each of the line item tasks and notes that trade on the form. Each form will have more than one trade responsible for its execution.

.5 The subcontractor responsible for the purchase of the equipment develops the full start-up plan by combining (or adding to) the CA's checklists with the manufacturer's detailed start-up and checkout procedures from the O&M manual and the normally used field checkout sheets. The plan will include checklists and procedures with specific boxes or lines for recording and documenting the checking and inspections of each procedure and a summary statement with a signature block at the end of the plan.

.6 The subcontractor submits the full startup plan to the CA for review and approval.

.7 The CA reviews and approves the procedures and the format for documenting them, noting any procedures that need to be added.

.8 The full start-up procedures and the approval form may be provided to the CM for review and approval, depending on management protocol.

.9 Execution of Prefunctional Checklists and Startup.

.10 Four weeks prior to startup, the Subs and vendors schedule startup and checkout with the CM, GC and CA. The performance of the prefunctional checklists, startup and checkout are directed and executed by the Sub or vendor. When checking off prefunctional checklists, signatures may be required of other Subs for verification of completion of their work.

.11 The CA shall observe, at minimum, the procedures for each piece of primary equipment, unless there are multiple units, (in which case a sampling strategy may be used as approved by the CM). In no case will the number of units witnessed be less than four on any one building, nor less than 20% of the total number of identical or very similar units.

.12 For lower-level components of equipment, (e.g., VAV boxes, sensors, controllers), the CA shall observe a sampling of the prefunctional and start-up procedures. The sampling procedures are identified in the commissioning plan.

.13 The Subs and vendors shall execute startup and provide the CA with a signed and dated copy of the completed start-up and prefunctional tests and checklists.

.14 Only individuals that have direct knowledge and witnessed that a line item task on the prefunctional checklist was actually performed shall initial or check that item off. It is not acceptable for witnessing supervisors to fill out these forms.

5. FUNCTIONAL PERFORMANCE TESTING

.1 This sub-section applies to all commissioning functional testing for all divisions.

.2 Objectives and Scope. The objective of functional performance testing is to demonstrate that each system is operating according to the documented design intent and Contract Documents. Functional testing facilitates bringing the systems from a state of substantial completion to full dynamic operation. Additionally, during the testing process, areas of deficient performance are identified and corrected, improving the operation and functioning of the systems.

.3 In general, each system should be operated through all modes of operation (seasonal, occupied, unoccupied, warm-up, cool-down, part- and full-load) where there is a specified system response. Verifying each sequence in the sequences of operation is required. Proper responses to such modes and conditions as power failure, freeze condition, low oil pressure, no flow, equipment failure, etc. shall also be tested.

.4 Development of Test Procedures. Before test procedures are written, the CA shall obtain all requested documentation and a current list of change orders affecting equipment or systems, including an updated points list, program code, control sequences and parameters. The CA shall develop specific test procedures and forms to verify and document proper operation of each piece of equipment and system. Each Sub or vendor

responsible to execute a test, shall provide limited assistance to the CA in developing the procedures review (answering questions about equipment, operation, sequences, etc.). Prior to execution, the CA shall provide a copy of the test procedures to the Sub(s) who shall review the tests for feasibility, safety, equipment and warranty protection.

.5 The CA shall review owner-contracted, factory testing or required owner acceptance tests which the CA is not responsible to oversee, including documentation format, and shall determine what further testing or format changes may be required to comply with the Specifications. Redundancy of testing shall be minimized.

.6 The purpose of any given specific test is to verify and document compliance with the stated criteria of acceptance given on the test form.

.7 Coordination and Scheduling. The Subs shall provide sufficient notice to the CA regarding their completion schedule for the prefunctional checklists and startup of all equipment and systems. The CA will schedule functional tests through the CM, GC and affected Subs. The CA shall direct, witness and document the functional testing of all equipment and systems. The Subs shall execute the tests.

.8 In general, functional testing is conducted after prefunctional testing and startup has been satisfactorily completed. The control system is sufficiently tested and approved by the CA before it is used for TAB or to verify performance of other components or systems. The air balancing and water balancing is completed and debugged before functional testing of air-related or water-related equipment or systems. Testing proceeds from components to subsystems to systems. When the proper performance of all interacting individual systems has been achieved, the interface or coordinated responses between systems is checked.

6. DOCUMENTATION, NON-CONFORMANCE AND APPROVAL OF TESTS

.1 Documentation. The CA shall witness and document the results of all functional performance tests using the specific procedural forms developed for that purpose. Prior to testing, these forms are provided to the CM for review and approval and to the Subs for review. The CA will include the filled out forms in the O&M manuals.

.2 The CA will record the results of the functional test on the procedure or test form. All deficiencies or non-conformance issues shall be noted and reported to the CM on a standard non-compliance form.

.3 Corrections of minor deficiencies identified may be made during the tests at the discretion of the CA. In such cases the deficiency and resolution will be documented on the procedure form.

7. OPERATION AND MAINTENANCE MANUALS

.1 The specific content and format requirements for the standard O&M manuals are provided in Divisions 15 and 16.

.2 In addition to standard O&M manuals, all Subs are required to submit all shop drawings in electronic format (PDF). The pdf files must be reasonably sized (less than 5 MB per file) and named and categorized on CD and/or FTP site.

.3 This work does not supersede the A/E's review of the O&M manuals according to the A/E's contract.

8. TRAINING OF OWNER PERSONNEL / PROPERTY MANAGEMENT / MAINTENANCE CONTRACTORS

.1 The GC shall be responsible for training coordination and scheduling and ultimately for ensuring that training is completed.

.2 The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment.

.3 All training sessions are to be videotaped as arranged by the GC.

.4 In addition to these general requirements, the specific training requirements of Owner personnel by Subs and vendors is specified in Division 15 and 16.

.5 Each Sub and vendor responsible for training will submit a written training plan to the CA for review and approval prior to training. The plan will cover the following elements:

(a) Equipment (included in training)

(b) Intended audience

(c) Location of training

(d) Objectives

(e) Subjects covered (description, duration of discussion, special methods, etc.)

(f) Duration of training on each subject

(g) Instructor for each subject

(h) Methods (classroom lecture, video, site walk-through, actual operational demonstrations, written handouts, etc.)

(i) Instructor and qualifications

.6 For the primary HVAC equipment, the Controls Contractor shall provide a short discussion of the control of the equipment during the mechanical or electrical training conducted by others.

.7 The CA develops an overall training plan and coordinates and schedules, with the CM and GC, the overall training for the commissioned systems. The CA develops criteria for determining that the training was satisfactorily completed, including attending some of the training, etc. The CA recommends approval of the training to the CM using a standard form. The CM also signs the approval form.

.8 The mechanical design engineer shall at the first training session present the overall system design concept and the design concept of each equipment section.

9. DEFERRED TESTING

.1 Unforeseen Deferred Tests. If any check or test cannot be completed due to the building structure, required occupancy condition or other deficiency, execution of checklists and functional testing may be delayed upon approval of the PM. These tests will be conducted in the same manner as the seasonal tests as soon as possible. Services of necessary parties will be negotiated.

.2 Seasonal Testing. During the warranty period, seasonal testing (tests delayed until weather conditions are closer to the system's design) shall be completed as part of this contract. The CA shall coordinate this activity. Tests will be executed, documented and deficiencies corrected by the appropriate Subs, with facilities staff and the CA witnessing. Any final adjustments to the O&M manuals and as-builds due to the testing will be made.

10. POST-OCCUPANCY REVIEW

.1 All subs must return to the site 10 months after substantial completion to participate in a walk-through conducted by the CA and property manager.

.2 The walk-through will address outstanding deficiencies, warranty issues, clean-up and project close-out.

PART 1 - GENERAL

1.1 This section describes the scope of mechanical testing requirements, which consist of:

.1 Prefunctional Checklists – Generally filled out by installing contractor for all commissioned equipment. **(**Sample prefunctional checklist follows at end of this section)

.2 Functional Checklists – Manual or self-contained equipment (e.g. Suite fan coils) filled out by installing contractor. Centralized equipment operated by BAS is filled out by Commissioning Authority.

1.2 Final checklists will be developed by the Commissioning Authority during the construction period and will be based on submitted shop drawings, final equipment specifications, and manufacturer requirements. Checklists will be issued to the contractor during the construction period.

1.3 Any tests described in this section are for illustrative purposes only and subject to change. The tests are included to inform bidders of the scope of contractor commissioning responsibilities.

1.4 All testing under the scope of "commissioning" is in addition to any and all other start-up, testing, and verification procedures described elsewhere in the contract documents.

PART 2 - SCOPE OF FUNCTIONAL TESTS

System or Equipment	Equipment or Component Tested	General Description of Modes and Functions to Test	Testing Method (Manual, BAS)	Sampling Strategy (list applicable equip.)	Who Executes Test	Seasonal Test Req'd (list applicable equip. & modes)
Chilled Water System	Chillers, primary and secondary CHW pumps, CDW pumps, cooling tower (CT), VFD, controls	All sequences of chiller and cooling tower and related pumps (startup, shutdown, load changes, resets, lead lag action, alarms, lockouts), VFD control, temporary power, chiller capacity and efficiency, CT capacity and efficiency, part load curves with manuf.	Mostly M, with some BAS	Test all including standby equip.	Mech. leads with help from: CA	Chiller test must be done in summer, CT in summer
Corridor Air handling systems	AHU, supply, return and exhaust fans, coils, coil pumps, valves, dampers, VFD, controls	All sequences of fans and related components (startup, shutdown, setup, unoccupied conditions, load changes, resets, alarms, lockouts), VFD control, operation of all dampers in all modes, all economizer modes, temporary power, coil capacity, coil effic., OSA control, bldg. pressure,	Mostly M, with some BAS	Test all	CA leads with help from Mech.	Must test in √ sum'r √ winter

System or Equipment	Equipment or Component Tested	General Description of Modes and Functions to Test	Testing Method (Manual, BAS)	Sampling Strategy (list applicable equip.)	Who Executes Test	Seasonal Test Req'd (list applicable equip. & modes)
In-Suite Fan Coil	Terminal units	Verify damper and fan sequences during heating, cooling, debands, occupied, unoccupied, verify flow	M	Test 28 random units (selected by CA)	Mech. leads with help from CA	No
Spot HVAC Units	Unit heaters, controls	All sequences, occupied, unoccupied, lockouts, simultaneous heating /cooling issues	M	Test 10% of identical and at least 5	Mech.	No, if htg & cooling condition is simulated
Specialty Fans	Stairwell pressuriz-ation fans, controls	Tested by fire officials	-	-	-	-
Parking Garage Fans	Fans, CO control system	On/off, local controls, overrides, alarms	M and BAS	Test all	CA with help from Mech.	No
Small Exhaust Fans	Eg. Locker room exhaust fans	Occupied, unoccupied, local controls, overrides, schedules, central controls	M	Test all	Mech.	No
Packaged HVAC	AHU, supply, return and exhaust fans, compressor, condensers, coils, valves, dampers, heating elements, VFD, controls	All sequences of fans and related components (startup, shutdown, setup, unoccupied conditions, load changes, resets, alarms, lockouts), VFD control, operation of all dampers in all modes, temporary power, OSA control, building pressure, compressor and cond. fan staging, heating COP & capacity, cooling EER & capacity	Mostly M with some BAS	Test all	Mech. Lead with help from: CA	No
TAB (Testing and Balancing)	Air and water TAB work	Primary air and water flows and terminal flows	M	All non-suite areas; Verify a % of TAB readings (see Specs)	TAB	No
Lighting Controls	Occupancy sensors	Occupied, unoccupied, overrides, sweep, varying daylight, occupancy, as applicable, occupant use	M	Test all	Elec. leads CA helps	No

Sample Prefunctional Checklist

Project: 300 Front Street West

PC-1: CORRIDOR AIR HANDLER UNITS, AHU-1 through AHU-2

Components included: ___supply fans, ___return and exhaust fans, ___coils, ___valves, ___VFD, ___dampers

Associated Checklists: HW Piping

1. Submittal / Approvals

Submittal. The above equipment and systems integral to them are complete and ready for functional testing. The checklist items are complete and have been checked off only by parties having direct knowledge of the event, as marked below, respective to each responsible contractor. This prefunctional checklist is submitted for approval, subject to an attached list of outstanding items yet to be completed. A Statement of Correction will be submitted upon completion of any outstanding areas. None of the outstanding items preclude safe and reliable functional tests being performed. ___ List attached.

_____ Mechanical Contractor	_____ Date	_____ Controls Contractor	_____ Date
_____ Electrical Contractor	_____ Date	_____ Sheet Metal Contractor	_____ Date
_____ TAB Contractor	_____ Date	_____ General Contractor	_____ Date

Prefunctional checklist items are to be completed as part of startup & initial checkout, preparatory to functional testing.

- This checklist does not take the place of the manufacturer's recommended checkout and startup procedures or report.
- Items that do not apply shall be noted with the reasons on this form (N/A = not applicable, BO = by others).
- If this form is not used for documenting, one of similar rigor shall be used.
- Contractors assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off.
- "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = architect/engineer, All = all contractors, CA = commissioning agent, CC = controls contractor, EC = electrical contractor, GC = general contractor, MC = mechanical contractor, SC = sheet metal contractor, TAB = test and balance contractor, ____ = _____.

Approvals. This filled-out checklist has been reviewed. Its completion is approved with the exceptions noted below.

_____ Commissioning Agent	_____ Date	_____ Owner's Representative	_____ Date

2. Requested documentation submitted

Check Equip Tag->	AHU-1	AHU-2
Manufacturer's cut sheets		
Performance data (fan curves, coil data, etc.)		
Installation and startup manual and plan		
Sequences and control strategies		
O&M manuals		

- ***Documentation complete as per contract documents for given trade.....___ YES ___ NO***

3. Model verification

1 = as specified, 2 = as submitted, 3 = as installed. Check if Okay. Enter note number if deficient.

Equip Tag--->		AHU-1	AHU-2
Manuf.	1		
	2		
	3		
Model	1		
	2		
	3		
Serial #	3		
Capacity	1		
	2		
	3		
Volts/phase	1		
	3		

- ***The equipment installed matches the specifications for given trade.....___ YES ___ NO***

4. Installation Checks

Check Equip Tag->	AHU-1	AHU-2
Cabinet and General Installation		
Permanent labels affixed, including for fans		
Casing condition good: no dents, leaks, door gaskets installed		
Access doors close tightly - no leaks		
Boot between duct and unit tight and in good condition		
Vibration isolation equipment installed & released from shipping locks		
Maintenance access acceptable for unit and components		
Sound attenuation installed		
Thermal insulation properly installed and according to specification		

Check Equip Tag->	AHU-1	AHU-2
Instrumentation installed according to specification (thermometers, pressure gages, flow meters, etc.)		
Clean up of equipment completed per contract documents		
Filters installed and replacement type and efficiency permanently affixed to housing--construction filters removed		
Piping and Coils		
No leaking apparent around refrigerant fittings		
All coils are clean and fins are in good condition		
All condensate drain pans clean and slope to drain per spec		
OSAT, MAT, SAT, RAT sensors properly located and secure (related OSAT sensor shielded)		
Sensors calibrated (See calibration section below)		
If split system, refrigerant piping in good condition and suction insulated		
P/T plugs and isolation valves installed per drawings		
Fans and Dampers		
Supply fan and motor alignment correct		
Supply fan belt tension & condition good		
Supply fan protective shrouds for belts in place and secure		
Supply fan area clean		
Supply fan and motor properly lubricated		
Return/exhaust fan and motor aligned		
Return/exhaust fan belt tension & condition good		
Return/exhaust fan protective shrouds for belts in place and secure		
Return/exhaust fan area clean		
Return/exhaust fan and motor lube lines installed and lubed		
Filters clean and tight fitting		
Filter pressure differential measuring device installed and functional (magnahelic, inclined manometer, etc.)		
Smoke and fire dampers installed properly per contract docs (proper location, access doors, appropriate ratings verified)		
All dampers close tightly		
All damper linkages have minimum play		
Low limit freeze stat sensor located to deal with stratification & bypass		
Ducts (preliminary check)		
Sound attenuators installed		
Duct joint sealant properly installed		
No apparent severe duct restrictions		
Turning vanes in square elbows as per drawings		
OSA intakes located away from pollutant sources & exhaust outlets		

Check Equip Tag->	AHU-1	AHU-2
Pressure leakage tests completed		
Branch duct control dampers operable		
Ducts cleaned as per specifications		
Balancing dampers installed as per drawings and TAB's site visit		
Electrical and Controls		
Pilot lights are functioning		
Power disconnects in place and labeled		
All electric connections tight		
Proper grounding installed for components and unit		
Safeties in place and operable		
Starter overload breakers installed and correct size		
Sensors calibrated (see below)		
Control system interlocks hooked up and functional		
Smoke detectors in place		
All control devices, pneumatic tubing and wiring complete		
VFD		
VFD powered (wired to controlled equipment)		
VFD interlocked to control system		
Static pressure or other controlling sensor properly located and per drawings and calibrated		
Static pressure or other controlling sensor calibrated		
Drive location not subject to excessive temperatures		
Drive location not subject to excessive moisture or dirt		
Drive size matches motor size		
Internal setting designating the model is correct		
Input of motor FLA represents 100% to 105% of motor FLA rating		
Appropriate Volts vs Hz curve is being used		
Accel and decel times are around 10-50 seconds, except for special applications. Actual decel = _____ Actual accel = _____		
Lower frequency limit at 0 for VAV fans and around 10-30% for chilled water pumps. Actual = _____		
Upper frequency limit set at 100%, unless explained otherwise		
Unit is programmed with full written programming record on site		
TAB		
Installation of system and balancing devices allowed balancing to be completed following specified NEBB or AABC procedures and contract documents		

Check **Equip Tag->**	**AHU-1**	**AHU-2**
Final		
Smoke and fire dampers and unpowered TU's are open		
Startup report completed with this checklist attached		
Safeties installed and safe operating ranges for this equipment provided to the commissioning agent		
If unit is started and will be running during construction: have quality filters on RA grills, etc. to minimize dirt in the ductwork and coils and in any finished areas. Verify moisture migration is not a problem, due to improper pressures between spaces.		

- ***The checklist items of Part 4 are all successfully completed for given trade.....___ YES ___ NO***

5. Operational Checks (These augment mfr's list. This is not the functional performance testing.)

Check **Equip Tag->**	**AHU-1**	**AHU-2**
Supply fan rotation correct		
Return/exhaust fan rotation correct		
Fans > 5 Hp Phase Checks: (%Imbalance = 100 x (avg. - lowest) / avg.) Record all 3 voltages in cell. Imbalance less than 2%?		
Record full load running amps for each fan. _____rated FL amps x _____srvc factor = _____ (Max amps). Running less than max?		
Return /exhaust fan acceptable noise & vibration		
Supply fan has no unusual noise or vibration		
Inlet vanes aligned in housing, actuator spanned, modulate smoothly and proportional to input signal and EMS readout		
All dampers (OSA, RA, EA, etc.) stroke fully without binding and spans calibrated and BAS reading site verified (follow procedure in Calibration and Leak-by Test Procedures). List dampers checked: _____		
The HOA switch properly activates and deactivates the unit		
Specified sequences of operation and operating schedules have been implemented with all variations documented		
Specified point-to-point checks have been completed and documentation record submitted for this system		

- ***The checklist items of Part 5 are all successfully completed for given trade.....___ YES ___ NO***

6. Sensor and Actuator Calibration [ ]

All field-installed temperature, relative humidity, CO, CO_2 and pressure sensors and gages, and all actuators (dampers and valves) on this piece of equipment shall be calibrated using the methods and tolerances given in the Calibration and Leak-by Test Procedures document. All test instruments shall have had a certified calibration within the last 12 months: Y/N_____. Sensors installed *in* the unit at the factory with calibration certification provided need not be field calibrated.

Sensor or Actuator & Location	Loca-tion OK	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?

Sensor & Location	Loca-tion OK	**1st** Gage or BAS Value	Instr. Meas'd Value	**Final** Gage or BAS Value	Pass Y/N?

Gage reading = reading of the permanent gage on the equipment. BAS = building automation system. Instr. = testing instrument. Visual = actual observation. The Contractor's own sensor check-out sheets may be used in lieu of the above, if the same recording fields are included and the referenced procedures are followed.

- ***All sensors are calibrated within required tolerances .....___ YES ___ NO***

-- END OF CHECKLIST--

PART 1 – GENERAL

1.1 GENERAL

1. This Section includes requirements for Construction Indoor Air Quality (IAQ) Management to prevent IAQ problems due to the construction process in order to help sustain comfort of construction personnel and building occupants. All Sections of Specifications involving construction activities apply to this section.

1.2 PERFORMANCE REQUIREMENTS

1. The General Contractor shall follow the Construction Indoor Air Quality Management Plan as listed below and perform the required execution procedures to meet credit requirements.

1.3 CONSTRUCTION INDOOR AIR QUALITY MANAGEMENT PLAN

1. Adhere to SMACNA IAQ Guideline During Construction:

    1. HVAC equipment must be protected from dust and odors.

    2. HVAC equipment to be shut down during heavy construction.

    3. System must be isolated from the surrounding environment as much as possible (e.g. all tiles in place for a ceiling plenum) to prevent induction of pollutants.

    4. Return system openings in or adjacent to construction areas must be sealed with plastic.

    5. Mechanical room can not be used to store construction or waste materials.

    6. If excessive duct or debris is present on ductwork, ductwork must be professionally cleaned following construction and prior to occupancy.

    7. Low-emitting and low-VOC products must be installed where specified.

    8. Idling of diesel vehicles is prohibited where emissions could be drawn into occupied areas.

    9. Local exhaust of pollution sources (e.g. temporary exhaust fans) must be in compliance with applicable regulations and should be directed well away from air intakes.

2. Protection of Absorptive Materials from Moisture Damage

    1. Insulation, drywall, and any other moisture absorptive interior finishes may not be installed until the building envelope is sealed to prevent moisture damage.

    2. When stored on site, sheet metal, insulation, and other ventilation materials must be stored on sleepers until immediately prior to installation to avoid moisture absorption and subsequent damage.

3. Air Handlers Used During Construction

    1. If air handlers are used during construction, filtration media with a Minimum Efficiency Reporting Value (MERV) of 8 must be used as determined by ASHRAE 52.2-1999.

4. Inspections and Deficiencies

    1. Make provisions for weekly inspections of building and HVAC systems for deficiencies that could adversely affect IAQ.

    2. Document correction of all deficiencies from inspections.

5. Building Flushout

    1. Allow scheduling provision for building flush-out of 1700 m^3 of outdoor air per m^2 of occupied floor area, after construction completion but prior to occupancy. Continue flush out of additional 2600 m^3 or outdoor air per m^2 of occupied floor area following occupancy.

1.4 INSPECTION AND DOCUMENTATION

1. The contractor shall designate one individual on site as the Construction IAQ Management Representative, and shall make provisions for bi-weekly inspections of building and HVAC systems for deficiencies that could adversely affect IAQ.

2. Documentation of correction of all deficiencies from inspections must take place.

3. Documentation may be in the form of the IAQ Management Inspection Form provided below, or an equivalent form developed by the contractor and approved by the Owner and LEED consultant.

4. All documentation shall be accompanied by photographs, highlighting both adherence to the plan, as well as deficiencies and subsequent correction. Photographs shall cover a range of the measures outlined in the CONSTRUCTION IAQ MANAGEMENT PLAN Section above.

1.5 LEED BUILDING SUBMITTALS

1. LEED Letter template (provided by LEED Consultant) signed by General Contractor, stating that the IAQ management has been developed and implemented.

2. Schedule of all filters and MERV values used during construction and at end of construction.

3. Letter verifying that any necessary corrections or mitigations resulting from inspections that could adversely affect IAQ have been completed.

4. IAQ Management Inspection Form, or approved equivalent form, provided to the Owner and LEED Consultant on a monthly basis.

5. Provide at a minimum 18 annotated digital photographs taken on 3 different occasions during construction in order to demonstrate adherence to the IAQ plan. Photographs may be attached to the IAQ Management Inspection Form.

1.6 REFERENCES

1. Sheet Metal and Air Conditioning Contractors National Association (SMACNA) IAQ Guideline for Occupied Buildings Under Construction, 1995, Chapter 3, pp. 3.1 – 3.5.

2. LEED Canada Rating System Reference Guide, v1.0, pp 365 – 373.

3. ASHRAE 52.2-1999.

PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

1. This Section includes requirements for volatile organic compound (VOC) content in adhesives and sealants, paints and coatings, carpet systems and composite wood used for the project. The criteria are included as part of the LEED Building requirements for the project.

2. Substitutions, or other changes to the work proposed by the Contractor or their Subcontractors, shall not be allowed if such changes substantially compromise the stated LEED Building criteria.

1.2 VOC REQUIREMENTS FOR ADHESIVES AND SEALANTS

1. The volatile organic compound (VOC) content of sealants, adhesives and all related primers used in this project shall not exceed the limits defined in Rule 1168 – "Adhesive and Sealant Applications" of the South Coast Air Quality Management District (SCAQMD), of the State of California, version in effect at date of application of building permit.

   The VOC limits defined by SCAQMD are given in *VOC LIMITS FOR ADHESIVE, SEALANTS, PAINTS, & COATINGS* attached at the end of this spec section.

1.3 VOC REQUIREMENTS FOR PAINTS & COATINGS

1. Paints and coatings used on the interior of the building (defined as inside of the weatherproofing system and applied on-site) shall comply with the following criteria:

   1. Architectural paints, coatings and primers applied to interior walls and ceilings: Do not exceed the VOC content limits established in Green Seal Standard GS-11, Paints, version in effect at date of application of building permit.

   2. Anticorrosive and anti-rust paints applied to interior ferrous metal substrates: Do not exceed the VOC content limits established in Green Seal Standard GC-03, Anti-Corrosive Paints, of the version in effect at date of application of building permit.

   3. Clear wood finishes, floor coatings, stains and shellacs applied to interior elements: Do not exceed the VOC content limits established in South Coast Air Quality Management District Rule 1113, Architectural Coatings, version in effect at date of application of building permit.

   4. Chemical Component Limitations - Aromatic Compounds: the product must contain no more than 1.0% by weight of the sum total of aromatic compounds. Testing for the concentration of these compounds will be performed if they are determined to be present in the product during a materials audit.

   5. Chemical Component Limitations - Other Chemicals: the manufacturer shall demonstrate that the following chemical compounds are not used as ingredients in the manufacture of the product.

      - Halomethanes: methylene chloride
      - Chlorinated ethanes: 1,1,1-trichloroethane

- Aromatic solvents: benzene, toluene (methylbenzene), ethylbenzene
- Chlorinated ethylenes: vinyl chloride
- Polynuclear aromatics: naphthalene
- Chlorobenzenes: 1,2-dichlorobenzene
- Phthalate esters: di (2-ethylhexyl) phthalate, butyl benzyl phthalate, di-n-butyl phthalate, di-n-octyl phthalate, diethyl phthalate, dimethyl phthalate
- Miscellaneous semi-volatile organics: isophorone
- Metals and their compounds: antimony, cadmium, hexavalent chromium, lead, mercury
- Preservatives (antifouling agents): formaldehyde
- Ketones: methyl ethyl ketone, methyl isobutyl ketone
- Miscellaneous volatile organics: acrolein, acrylonitrile

6. The VOC limits are given in *VOC LIMITS FOR ADHESIVE, SEALANTS, PAINTS, & COATINGS* attached at the end of this spec section.

1.4 VOC REQUIREMENTS FOR CARPETS

1. Carpet systems must meet or exceed the requirements of the Carpet and Rug Institute's Green Label Indoor Air Quality test Program as shown below:

1. Maximum Emission Factor (mg/m < or = Jhr) for Carpets
www.carpet-rug.com/drill_down_2.cfm?page=8&sub=6

Total Volatile Organic Compounds 0.5	
4-PC (4-Phenylcyclohexene)	0.05
Formaldehyde	0.05
Styrene	0.4

2. Maximum Emission Factor (mg/m < or = Jhr) for Cushions
www.carpet-rug.com/drill_down_2.cfm?page=8&sub=7

Total Volatile Organic Compounds 1.00	
4-PC (4-Phenylcyclohexene)	0.05
Formaldehyde	0.05
BHT (butylated hydroxytoluene)	0.40

3. Maximum Emission Factor (mg/m < or = Jhr) for Adhesives
www.carpet-rug.com/drill_down_2.cfm?page=8&sub=8

Total Volatile Organic Compounds 10.00	
2-Ethyl-1-Hexanol	3.00
Formaldehyde	0.05

1.5 SUBMITTALS

1. For adhesives, sealants, paints and coatings, provide cut sheets, Material Safety Data sheets (MSDS), signed attestations or other official literature from manufacturers clearly identifying VOC content in grams per Litre (g/L). VOC content reported in % by weight is not acceptable.

2. For carpet systems, provide documentation indicating the product meets the requirements of the Carpet and Rug Institute's Green Label Indoor Air Quality test Program

3. For each product, complete the ENVIRONMENTAL BUILDING MATERIALS CERTIFICATION FORM provided by the sustainability consultant. Fill in all relevant sections related to VOC content, urea-formaldehyde content or Carpet and Rug Institute Green Label certification, as applicable. State actual VOC content of each product used. Attach cut sheets, Material Safety Data sheets (MSDS), signed attestations or other official literature from manufacturers to this form.

4. Provide one copy of submittals listed above for review by LEED Consultant at least two weeks prior to purchase. Trades and suppliers must provide this documentation to the Contractor prior to the commencement of work.

1.6 REFERENCES

1. Rule 1168 – "Adhesive and Sealant Applications" South Coast Air Quality Management District (SCAQMD), State of California, www.aqmd.gov

2. Green Seal Standard GS-11 – Paints and GC-03 Anit-Corrosive Paints, www.greanseal.org

3. Rule 1113 – "Architectural Coatings" South Coast Air Quality Management District (SCAQMD), State of California, www.aqmd.gov

4. Carpet and Rug Institute Green Label Testing Program. http://www.carpet-rug.com/drill_down_2.cfm?page =8&sub=3&requesttimeout=350

5. Carpet and Rug Institute, www.carpet-rug.com

END OF SECTION

VOC LIMITS FOR ADHESIVE, SEALANTS, PAINTS, & COATINGS

EQc4.1 - Adhesives and Sealants	
Product Type	Max. VOC content (g/L)
Adhesives and Adhesive Primers	
Architectural Applications	
Carpet pad adhesive	50
Ceramic tile adhesive	65
Cove base adhesive	50
Drywall and panel adhesive	50
Indoor carpet adhesive	50
Multipurpose construction adhesive	70
Outdoor carpet adhesive	150
Rubber floor adhesive	60
Single ply roof membrane adhesives	250
Structural glazing adhesive	100
Subfloor adhesive	50
VCT and asphalt tile adhesive	50
Wood flooring adhesive	100

EQc4.2 - Paints and Coatings	
Product Type	Max. VOC content (g/L)
Paints and Primers	
Anti-Corrosive Coating	250
Flat Coatings*	50
Floor Paint	100
Non-Flat Coatings*	100
Primer, Undercoat	100
Reflective Wall Coating	50
Other Architectural Coatings	
Bond breaker	350
Clear Brushing Lacquer	275
Clear Wood Finish – Lacquer	275
Clear Wood Finish – Sanding Sealer	275
Clear Wood Finish – Varnish	275
Concrete-Curing Compound	100
Dry-fog coating	150

Specialty Applications	
ABS welding	325
Adhesive primer for plastic	250
Adhesive Primer for Traffic Marking Tape	150
Contact Adhesive	80
CPVC welding	270
Plastic cement welding	250
PVC welding	285
Sheet Applied Rubber Lining Operations	850
Special Purpose Contact Adhesive	250
Structural Wood Member Adhesive	140
Substrate Specific Applications	
Fiberglass	80
Plastic foams	50
Porous material (except wood)	50
Metal to metal	30
Wood	30
Sealants and Sealant Primers	
Sealants	
Architectural	250
Nonmembrane Roof Installation/Repair	300
Roadways	250
Single Ply Roof Material Installation/Repair	450
Other	420
Sealant Primer	
Architectural – Nonporous	250
Architectural – Porous	775
Other	750

Notes
Materials/products that are within the building's weatherproofing layer must comply with the given VOC limits.
*A coating is considered flat if it has a gloss of less than 5 on a 60-degree meter, or less than 15 on an 85-degree meter. If the gloss is greater than these values, the coating is considered non-flat. VOC limits for paints are based on no colour added at point-of-sale.

Fire-Proofing Exterior Coating	350
Fire-Retardant Coating – Clear	650
Fire-Retardant Coating – Pigmented	350
Floor Coatings	50
Graphic Arts (sign) Coating	500
Japan/Faux Finishing Coating	350
Low-Solids Coating	120
Magnesite Cement Coating	450
Mastic Coating	300
Metallic Pigmented Coating	500
Multi-Colour Coating	250
Pigmented Lacquer	275
Pre-Treatment Wash Primer	420
Primer, Sealer, or Undercoat	100
Quick-Dry Enamel	50
Quick-Dry Primers, Sealers, Undercoats	100
Recycled Coatings	250
Roof Coating	50
Roof Coatings, Aluminum	100
Rust Preventative Coatings	100
Shellac – Clear	730
Shellac – Pigmented	550
Specialty Primers	100
Stain	100
Stain, Interior	250
Swimming Pool Coating – Repair	340
Swimming Pool Coating – Other	340
Traffic Coating	100
Waterproof Sealer	100
Wood Preservative – Below-Ground	350
Wood Preservative – Other	350
Industrial Maintenance Primers and Topcoats	
Industrial Maintenance Coatings	100
High Temperature IM Coatings	420
Zinc-Rich IM Primers	100