TLDSB
PARKVIEW PS
HVAC UPGRADES

MECHANICAL/ELECTRICAL SPECIFICATIONS

SAB Engineering Inc.

588 Edward Ave. unit 25, Richmond Hill, Ont. L4C 9Y6

Phone: 905-787 8885

E-mail: sabengineering@rogers.com

Prepared for: TLDSB

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MECHANICAL REQUIREMENTS

MECHANICAL INSULATION

FLUID TRANSFER

AIR HANDLING

DIGITAL CONTROLS

ELECTRICAL

PART1 - GENERAL

1.1 WORK INCLUDED IN THIS SECTION

.1 Demolition work will include the complete removal of the existing exhaust fan and associated ductwork as shown on drawings, as well as:

.1 Section of roof as required for the installation of new roof-curb.

.2 Structural and General work

.3 All associated electrical work as per Electrical Drawings.

.4 All cutting and patching associated with this project is included.

.5 The temporary removal of any other building services as required for the installation of the new equipment; upon completion of the work, the relocated equipment shall be relocated back to the original position or left in the new position, as warranted by the new layout.

.6 All existing building services not affected by this work shall be protected and where necessary, maintained operational during and after the demolition work is complete. Any accidental damage or interruption of existing building services not required by this project will be promptly repaired at no additional cost to the Board.

1.2 QUALIFICATIONS

.1 Work of this section shall be executed by trades personnel having a minimum of five years experience in the demolition field and capable to deploy adequate equipment as required to complete the work in an efficient and orderly

1.3 EXAMINATION

.1 Examine existing property. Determine the nature of materials to be removed.

1.4 SALVAGE

.1 The Board Representative will review the Site prior to commencement of demolition and instruct the Contractor, in writing, as to the items to be retained for re-use or be turned over to the Board. In the absence of such specific instructions, materials from demolition shall become property of Mechanical Contractor who shall promptly remove all salvageable material and debris from Site.

.2 Remove and store indicated items for future use by the Board. Remove, handle and transport such items to storage area designated by the Board Representative. Perform such work carefully and with diligence to prevent any damage to the items during removal and in storage. Store material to be salvaged, neatly on wooden pallets, where directed by Board.

1.5 MAINTAINING TRAFFIC

.1 Maintain and preserve Board's access requirements within, to and from existing building in areas where demolition and removal work is being carried out.

.2 Do not close, obstruct, place or store material in Board's driveways and passageways. Conduct operations with minimum interference with roads, streets, driveways, user traffic and passageways.

1.6 HAULING OPERATIONS

.1 Maintain roadways and paving in the hauling areas clean on a daily basis and as required by Municipal Authorities.

1.7 INTERRUPTIONS TO BOARD'S OPERATIONS

.1 There will be absolutely no interruptions to the School schedule during demolition work. Therefore, it is imperative that operations and machine and equipment movements, deliveries and removals are executed at time or times that will permit uninterrupted Board's operations in and around the school, including parking, receiving areas, deliveries and site and access and egress.

.2 Where interruptions of domestic cold and hot water are necessary, coordinate with the School Representatives the timing and duration of such interruptions.

1.8 SAFETY REQUIREMENTS

.1 Coordinate posting of danger signs conspicuously around property. Close doorways and thoroughfares giving access to area of demolition with barricades.

.2 Provide a competent, experienced supervisor in charge of the Work and on Site while Work is in progress.

.3 Should any suspect designated substance not already identified, be encountered, cease work in the immediate area and immediately report, to the Board. Board is responsible for removal of designated substances.

1.9 PROTECTION

.1 Prevent movement, settlement or damage of adjacent structures, services, walks, paving, parts of existing building to remain. Make good any collateral damage caused by demolition.

.2 Take precautions to support affected structures and, if safety of building being demolished or adjacent structures or services appears to be endangered, cease operations and notify Board.

.3 Prevent debris from blocking drainage systems (floor drains) or other mechanical and electrical systems that must remain in operation.

.4 Protect building floors against damage from demolition work. Use ½" plywood covers over floor where lifting, moving, rolling of removed equipment is anticipated. Be responsible for repairing any damage to flooring caused by the work defined in this section. Execute repairs to the satisfaction of the Board at no cost to the Board.

PART2 - Products

Not applicable

PART3 - Execution

3.1 DEMOLITION

.1 At the end of each day's work, leave site in a safe condition and erect safety bariers and lights as required. Ensure that no parts of the existing building are in danger of collapsing.

.2 Review the requirements of new equipment to be installed. Perform all demolition work required to allow for the new equipment to be installed, wether shown on the drawings or not.

.3 Control dust and dirt produced during demolition.

.4 Provide any additional labour, materials and services not specifically indicated on the drawings but required to complete the work.

.5 Dispose of demolished materials in accordance with the requirements of Authorities Having Jurisdiction.

.6 At the end of demolition work, leave site in broom-clean condition. Clean existing surfaces specified to receive new applied finishes to ensure proper adherence.

.7 Do not disturb adjacent structures or equipment designated to remain in place.

.8 Confine operations and workers to those parts of the building which are defined on the drawings and exercise great care not to damage existing construction beyond that necessary for the carrying out of new work. Make good any such damage in every respect, to the satisfaction of the Board.

- END -

Part 1 - General

1.1 GENERAL

.1 This section of the specification is an integral part of the Contract Documents and shall be read accordingly.

1.2 DUTIES OF MECHANICAL CONTRACTOR

.1 The mechanical contractor shall assume the responsibilities and duties including but not limited to the ones described below:

.1 Superintendence

1 Provide full time on-site superintendent personnel and supporting staff with proven experience in project of similar value and complexity.

2 Site superintendent shall have over-all authority to speak for and represent the mechanical contractor.

.2 Coordination

1 Coordinate the work with all the sub-trades involved to ensure that the work will be carried out on schedule and in proper sequence.

2 Take complete responsibility for all remedial work that results from failure to coordinate any aspect of the mechanical work prior to its fabrication and/or installation.

3 Take responsibility for the delivery of equipment necessary to complete the work in accordance with the approved schedule.

.3 Staffing and Scheduling

1 Within seven days after the award of the contract, the Mechanical Contractor shall provide to the Board representative the following information:

- Appointment of official representatives in the project.
- Schedule of work.
- Delivery schedule for specified equipment.
- Requirements for temporary facilities, site signs, storage, etc.

.2 Work Completion Meeting

.1 Prior to application for Substantial Performance of the Work, the mechanical contractor shall participate in the take-over meeting.

.2 Agenda to include the following:

1 Review of outstanding deficiencies.
2 Submission of maintenance manuals, warranties and as-built drawings.
3 Results of performance tests and described further in this section.
4 Scheduling of training to Board's personnel.

1.3 **INTENT**

.1 Bidders for this work shall include for all labor, material, equipment and all other related cost including all applicable taxes (except HST) and fees to provide the full air handler system replacement as indicated on the drawing and specified herein.

.2 The work includes but is not limited to the following:

.1 The supply and installation of new air handling and split A/C equipment as shown on the drawings and specified herein.

.2 Installation of new ductwork, grilles, diffusers, as shown on the drawings and specified herein.

.3 Installation of roof curb(s) including all necessary roof work as per details on the drawings.

.4 Structural and General work

.5 Supply and installation of new gas piping as per drawings

.6 Performing air balancing as shown on the drawings and specified herein.

.7 Expanding the existing BAS controls for the operation of the new equipment to achieve the sequence of controls noted on the drawings. Provide all required wiring, conduits, panels and devices for a complete installation. Refer to Section 15900 for details.

.8 Providing power for the new equipment, including wiring, conduits, disconnects, starters, as required and as per drawings and specifications. Refer to Electrical drawings for detailed scope.

.9 Provide all the required supports, hangers as required for a complete installation. Maintain all wiring and piping at least 12" above roof level when run on roof.

.10 Patch, paint to match existing any surfaces affected by the work under this contract, including walls, floors, ceilings and roof.

.11 All roof work associated with this project including installation of supports, flashing, reinforcement and roof repair to match existing is part of this contract.

.3 Misinterpretation of any requirement of the drawings and specifications will not relieve the Mechanical Contractor of responsibility. If in any doubt, the Mechanical Contractor shall contact the Board for written clarification prior to submitting a bid for the Work.

1.4 INTERFERENCES

.1 The mechanical drawings do not show all the architectural and structural details, and any information involving accurate measuring of the building shall be taken at the building. Make without additional charge, any necessary changes or additions to the runs of drains, pipes, ducts, etc., to accommodate the above conditions. The location of equipment may be altered without charge providing the change is made before installation and does not necessitate major additional material.

.2 Wherever differences occur between specifications, or schematics and drawings, the maximum conditions shall govern and the bid shall be based on whichever information indicates the greater cost.

.3 Field verifications of dimensions on plans shall be made since actual locations, distances, and levels will be governed by actual field conditions.

.4 Discrepancies between different plans, or between plans and actual field conditions, or between plans and specifications shall promptly be brought to the attention of the Consultant for a decision.

.5 Install all mechanical services including but not exclusive to drains, pipes, and ducts, to conserve headroom and interfere as little as possible with the free use of the space through which they pass. All drains, pipes, ducts, etc., particularly those which may conflict with other trades, shall be installed only after the locations have been approved by the Consultant.

.6 Before commencing work, check and verify all grade and invert elevations, stacks, levels, and dimensions, to ensure proper and correct installation of the work.

.7 In addition to the work specifically mentioned in these Specifications and shown on the drawings, provide all other items that are obviously necessary to make a complete working installation, including those required by the Authorities Having Jurisdiction over the work.

1.5 EXAMINE SITE

.1 Prior to submitting the tender price, examine the site and the local conditions affecting the work. Examine carefully all drawings and the complete specifications to ensure that the work can be satisfactorily carried out as shown.

.2 No allowance will be made later for any expenses incurred through the failure to make these examinations or to report any such discrepancies in writing to Board.

1.6 SUBCONTRACTOR'S SHOP

.1 Provide Job site office, work-shop, tools, scaffolds, material storage, etc., as required to complete the work.

1.7 CLEANING

.1 During the performance of the work and on the completion, remove from the place of the work all debris, rubbish and waste materials caused by the performance of the work. Remove all tools and surplus materials after completion and acceptance of the work.

.2 All equipment shall be thoroughly vacuumed out at the time of final acceptance of the work.

1.8 DELIVERY, STORAGE AND HANDLING

.1 Protection of Equipment:

.1 Equipment and material placed on the job site shall remain in the custody of the Contractor until phased acceptance, whether or not the Board has reimbursed the Contractor for the equipment and material. The Contractor is solely responsible for the protection of such equipment and material against any damage.

.2 Place damaged equipment in first class, new operating condition; or, replace same as determined and directed by the Consultant. Such repair or replacement shall be at no additional cost to the Board.

.3 Protect interiors of new equipment and piping systems against entry of foreign matter. Clean both inside and outside before painting or placing equipment in operation.

.4 Existing equipment and piping being worked on by the Contractor shall be under the custody and responsibility of the Contractor and shall be protected as required for new work.

.2 Cleanliness of Piping and Equipment Systems:

.1 Exercise care in storage and handling of equipment and piping material to be incorporated in the work. Remove debris arising from cutting, threading and welding of piping.

.2 Piping systems shall be flushed, blown or pigged as necessary to deliver clean systems.

.3 Clean interior of all tanks prior to delivery for beneficial use by the Board.

.4 Contractor shall be fully responsible for all costs, damage, and delay arising from failure to provide clean systems.

1.9 INSTALLATION OF WORK

.1 Be responsible for:

.1 The layout of the work shown on the drawings and specified herein, and for any

damage caused to the Board by improper location or carrying out of this work.

.2 The prompt installation of the work in advance of concrete pouring or similar work.

.3 The condition of all material and equipment supplied and for the protection and maintenance of work completed.

.2 Coordinate with all trades and schedule all work to suit the date for the substantial performance established in the construction contract.

.3 Furnish items to be "built-up" in ample time and give necessary information and assistance in connection with the building in of the same.

.4 Proceed with the work as quickly as practical so that construction may be completed in as short a time as possible and in accordance with the building schedule.

.5 Ensure that all equipment and material is ordered in time to meet the building schedule. Provide a schedule of equipment deliveries to the Board within the time limit stipulated.

.6 Furnish promptly information required for the construction schedule.

.7 Manufactured products supplied with instructions for their installation shall be installed in strict accordance with those instructions.

1.10 CODES, PERMITS, FEES AND CONNECTIONS

.1 Conform to Federal, Provincial and Municipal regulations and perform work in accordance with requirements of By-Laws and Regulations in force in area where the work will take place.

.2 Apply for, obtain, and pay for all permits, fees and service connections for the work and the inspections required by Authorities Having Jurisdiction in the area where the work will take place.

.3 For information, a specific code or standard might be mentioned. This information must not be taken as the only code or standard applicable.

.4 When part of equipment does not bear the required CSA label, the contractor shall obtain from CSA or Hydro Electric Power Commission, when that part of the equipment is an electric component, a special approval and pay the applicable fees.

.5 Furnish necessary certificates as evidence that the work installed conforms with laws and regulations of Authorities having jurisdiction. Changes in work requested by an Authority having jurisdiction shall be carried out without charge..

1.11 MATERIALS

.1 Where materials, equipment, apparatus, or other products are specified by the manufacturer, brand name, type or catalogue number, such designation is to establish

standards of desired quality style or dimensions and shall be the basis of the Bid. Materials so specified shall be furnished under this Contract.. Where two or more designations are listed, the contractor shall choose one of those listed and state the choice made on the Bid Form or Supplementary Tender Form (where applicable)

1.12 MATERIAL SUBSTITUTIONS

.1 After execution of the Contract, requests for substitution of materials of makes other than those specifically named in the Contract Documents may be reviewed and approved by the Consultant, subject to Board's review and acceptance of the financial credits involved.

.2 In the absence of such express approval by the Consultant, the Mechanical Contractor will be held to furnish specified items under the base bid.

1.13 SHOP DRAWINGS AND SAMPLES

.1 Submit to the Consultant detailed dimension shop drawings and installation wiring diagrams for all mechanical and associated electrical equipment. Further details and special requirements called for in these specifications shall be shown on the shop drawings.

.2 Ensure that copies of all reviewed shop drawings are available on the job site for reference.

.3 Provide samples of mechanical equipment as requested in the specification at the same time as the shop drawing submission.

1.14 AS-BUILT DRAWINGS

.1 Maintain up to date "as built" drawings on site and submit to Consultant for review in an electronic format at completion of the project as specified in this section.

.2 The "as-built" drawings shall be submitted in electronic format (AutoCad 2007 or higher). For the purpose of producing the "as-built" drawings, the Consultant shall provide the Contractor a set of tender documentation files, to be used as backgrounds.

.3 Any subsequent changes found by the Consultant shall remain the responsibility of the Contractor at no charge to the Board.

1.15 TEMPORARY AND TRIAL USAGE

.1 After any part of the work has been completed, the Consultant will make an inspection, and performance tests of such parts shall be carried out under the direction of the Consultant. If deficiencies are found, they shall be immediately rectified to the satisfaction of the Consultant. After such deficiencies have been rectified, the work shall be placed in service at such time and in such order as the Consultant may direct. If, in placing a portion of the equipment in service, it is necessary to make temporary

connections in the wiring in order to obtain proper operation, such connections shall be provided to the extent and in the manner required by the Consultant.

.2 Temporary or trial usage of any mechanical devices, machinery, apparatus, equipment or materials shall not be construed as evidence of the acceptance of same.

.3 No claims for damage will be considered for injury to, or the breaking of any parts of such work which may be used.

1.16 CONSULTANT'S INSTRUCTIONS

.1 During construction the Consultant will issue such instructions as may be necessary for verification and correction of the work. These instructions shall be binding as part of the specification.

1.17 ADDITIONAL WORK AND CHANGES

.1 Unless a written order, reviewed by the Consultant and countersigned or otherwise approved by the Board Representative, no additional work shall be undertaken by the Contractor.

1.18 WARRANTY

.1 The Mechanical Contractor shall guarantee all work and apparatus installed under his contract against all defects of workmanship and material for a period of one (1) year after the Substantial Performance of the Work, unless otherwise mentioned in the Specifications, and shall make good any and all defects developing during such time without expense to the Board. Any materials shall be further guaranteed as may be called for in these specifications. Where warranties on equipment extend beyond one (1) year the Mechanical Contractor shall honor the extended warranty.

.2 For BAS components warranty, refer to section 15900. Provisions of section 15900 over-ride warranty provisions of this section.

1.19 CASH ALLOWANCES

.1 Expenditures from the cash allowances may be made only upon receipt of an order signed by the Consultant and counter-signed by the Owner Representative. Payments shall be made only upon submission of the invoice for the work.

.2 Any unspent balance of the cash allowances shall be credited from the contract value and returned to the Owner.

.3 Carry cash allowances for the following:

.1 Reserved

1.20 SEPARATE PRICE

.1 Provide separate prices for the items listed as individual prices on the Supplementary Tender Form and **DO NOT** include them in the overall price. The separate prices shall include for all labor and material required to complete the work described under the respective paragraphs in the Bid Form.

.2 Provide separate prices for the following work:

.1 Reserved.

1.21 SCHEDULING OF WORK

.1 For all work to be performed under this contract, adhere to Construction Schedule agreed upon with the Board Representative.

1.22 ENERGY CONSUMPTION

.1 The Consultant may reject equipment submitted for approval on basis of performance or energy consumed or demanded.

.2 All equipment installed on the project shall conform to the requirements outlined in ASHRAE 90.1.

1.23 ELECTRIC MOTORS

.1 Electrical work to conform to Division 16 including the following:

.1 Except where specified otherwise in Division 16, Division 15 shall provide all control wiring and interlocks as may be required by the mechanical equipment.

.2 Quality of materials and workmanship shall be strictly in conformance with Division 16.

.3 All loose starters and disconnects are supplied and installed by Div. 16.

.4 Division 15 shall review the shop drawings for the motor starters submitted by Division 16 to ensure that all field connections are shown, motor horsepowers and voltages are correct and that the motor control schematic reflects all mechanical requirements.

.2 Provide motors for mechanical equipment as specified.

.3 If delivery of specified motor will delay delivery or installation of any equipment, install an acceptable motor for temporary use. Final acceptance of equipment will not occur until specified motor is installed.

.4 All motors shall be manufactured and installed in accordance with CSA requirements.

.5 Motor speed shall be 1750 rpm unless otherwise specified.

.6 All motors shall be "T" frame CEMA Standard Design "B" with Class "B" insulation, 40°C ambient, standard drip-proof with a 1.15 service factor, or as otherwise specified. Motors in air stream or exposed shall be TEFC type.

.7 Motors shall be of adequate size to operate associated equipment and drive mechanisms under all conditions of load and service and to bring equipment up to operating speed within 13 seconds without overloading, and be not less than the nameplate HP specified or indicated on the Drawings.

.8 Integral HP motor sizes ½ HP and above shall be squirrel cage induction motors rated 575 volt or 230volt, 3 phase, 60 hertz, unless noted otherwise.

.9 Fractional HP motors up to but not including ½ HP shall be rated 120 volt, single phase, 60 hertz and will be capacitor start, induction motors, with adequate thrust capacity when used with direct mounted equipment, and shall be provided with integral overload and overheating protection. Shaded pole starting devices will not be accepted.

.10 Multi-speed motors and associated switching devices shall be circuited to protect the motor at each speed.

.11 All motors, 1 HP and up shall comply with the Ontario Hydro EnerMark Motor Efficiency Level as tested either CSA 390 M 1985, or IEEE 112B, and be approved under the Canadian Electrical Safety Code.

.12 All starter panels shall be lockable and supplied with locks.

.13 Special Requirements:

.1 Where motor power requirements of equipment furnished deviate from power shown on plans, provide electrical service designed under the requirements of NFPA 70 without additional time or cost to the Owner.

.2 Assemblies of motors, starters, controls and interlocks on factory assembled and wired devices shall be in accordance with the requirements of this specification.

.14 Wire and cable materials specified in the electrical division of the specifications shall be modified as follows:

.1 Wiring material located where temperatures can exceed 71 degrees C (160 degrees F) shall be stranded copper with Teflon FEP insulation with jacket. Other wiring at air handlers and to control panels shall be NFPA 70 designation THWN.

.2 Provide shielded conductors or wiring in separate conduits for all instrumentation and control systems where recommended by manufacturer of equipment.

.15 Select motor sizes so that the motors do not operate into the service factor at maximum required loads on the driven equipment. Motors on pumps shall be sized for non-overloading at all points on the pump performance curves.

.16 Motors utilized with variable frequency drives shall be rated “inverter-ready” per NEMA Standard, MG1, Part 31.4.4.2. Provide motor shaft grounding apparatus that will protect bearings from damage from stray currents.

.17 Insulation Resistance: Not less than one half meg-ohm between stator conductors and frame, to be determined at the time of final inspection

1.24 EQUIPMENT REQUIREMENTS AND INSTALLATION

.1 Permit equipment maintenance and disassembly by use of unions or flanges to minimize disturbance to connecting piping and duct systems and without interference from building structure or other equipment.

.2 Provide accessible means for lubricating equipment including permanent lubricated bearings.

.3 For all indoor base mounted air handling units, fans and other rotating equipment, provide chamfered edge housekeeping pads a minimum of 4" high and 4" larger than equipment dimensions all around. Work shall be performed by the trades specializing in this work.

.4 Pipe drain lines, overflows and safety relief vents to drains. If the horizontal drains present a tripping hazard, use aluminum checkered plate covers.

.5 Line-up equipment, rectangular cleanouts and similar items with building walls wherever possible.

1.25 DRIVE GUARDS

.1 For machinery and equipment, provide guards as shown in AMCA 410 for belts, chains, couplings, pulleys, sheaves, shafts, gears and other moving parts regardless of height above the floor to prevent damage to equipment and injury to personnel. Drive guards may be excluded where motors and drives are inside factory fabricated air handling unit casings.

.2 V-belt and sheave assemblies shall be totally enclosed, firmly mounted, non-resonant. Guard shall be an assembly of minimum 22-gage sheet steel and expanded or perforated metal to permit observation of belts. 25 mm (one-inch) diameter hole shall be provided at each shaft centerline to permit speed measurement.

.3 Materials: Sheet steel, cast iron, expanded metal or wire mesh rigidly secured so as to be removable without disassembling pipe, duct, or electrical connections to equipment.

.4 Access for Speed Measurement: 25 mm (One inch) diameter hole at each shaft center.

1.26 LIFTING ATTACHMENTS

.1 Provide equipment with suitable lifting attachments to enable equipment to be lifted in its normal position. Lifting attachments shall withstand any handling conditions that might be encountered, without bending or distortion of shape, such as rapid lowering

and braking of load.

1.27 HAULING AND CRANE OPERATIONS

.1 Contractor is responsible for all crane operations required for the removal of the existing equipment and installation of the new one.

.2 Coordinate with the Owner any crane operation. Provide a crane plan for approval by the Owner and Consultant prior to any lift scheduling.

.3 Obtain all required permits for the crane lift (s).

1.28 THERMOMETERS AND PRESSURE GAUGES

.1 General:

.1 Locate direct reading thermometers and gauges for reading from floor or platform.

.2 Provide remote reading thermometers and gauges where direct reading instruments cannot be satisfactorily located.

.3 Locate engraved lamacoid nameplate as specified in Section Identification, identifying medium adjacent to thermometers and gauges.

.2 Thermometers:

.1 Industrial, 9" adjustable angle cast aluminum case, CGSB standard CAN/CGSB-14.4-M88 red reading mercury, lens front tube, white scale black embossed figures, clear glass or acrylic window, tapered aluminum stem.

.2 Scale shall be suitable for 2 times the temperature range of service. Scale shall be combined Celsius and Fahrenheit.

.3 Standard of Acceptance: Weiss, Ashcroft, Trerice.

.3 Pressure Gauges:

.1 5" dial, solid front blow out back, fibreglass reinforced polypropylene case, phosphor bronze bourdon tube and brass 1/4" N.P.T. socket, bottom connection, stainless steel rotary type movement, gauge to be registered with the Provincial Boiler and Pressure Vessel Safety Branch with a registration number and conform to ANSI B40.1. Accuracy to be grade "A".

.2 On pumps liquid filled gauges shall be utilized.

.3 Standard of Acceptance: Weiss, Ashcroft, Trerice.

.4 Provide bronze stop cock, bronze bar stock 1/4" N.P.T. bronze porous core pressure snubber for pulsating operation and diaphragm for corrosive service.

.5 Use materials compatible with system requirements.

.6 Gauges shall have combined kilopascal and psi scales.

1.29 PIPE HANGERS AND SUPPORTS - INDOORS

.1 General

.1 Pipe Supports: Comply with MSS SP 58. Type Numbers specified refer to this standard. For selection and application comply with MSS SP 69.

.2 Attachment to Concrete Building Construction:

.1 Concrete insert: MSS SP-58, Type 18.

.2 Self drilling expansion shields and machine bolt expansion anchors: Permitted in concrete not less than 102 mm (four inches) thick when approved by the Consultant for each job condition.

.3 Power driven fasteners: Permitted in existing concrete or masonry not less than 102 mm (four inches) thick when approved by the Resident Engineer for each job condition.

.3 Attachment to Steel Building Construction:

.1 Welded attachment: MSS SP 58, Type 22.

.2 Beam clamps: MSS SP-58, Types 20, 21, 28 or 29. Type 23 C clamp may be used for individual copper tubing up to 23mm (7/8 inch) outside diameter.

.4 Attachment to Metal Pan or Deck:

.1 As required for materials specified.

.5 Attachment to Wood Construction:

.1 Wood screws or lag bolts.

.6 Hanger Rods

.1 Hot rolled steel, ASTM A36 or A575 for allowable load listed in MSS SP 58. For piping, provide adjustment means for controlling level or slope. Types 13 or 15 turn buckles shall provide 38 mm (1 1/2 inches) minimum of adjustment and incorporate locknuts. All thread rods are acceptable.

.7 Hangers Supporting Multiple Pipes (Trapeze Hangers):

.1 Galvanized, cold formed, lipped steel channel horizontal member, not less than 41

mm by 41 mm (1 5/8 inches by 1 5/8 inches), 2.7 mm (No. 12 gage), designed to accept special spring held, hardened steel nuts. Not permitted for steam supply and condensate piping.

.2 Allowable hanger load: Manufacturers rating less 91kg (200 pounds).

.3 Guide individual pipes on the horizontal member of every other trapeze hanger with 6 mm (1/4 inch) U bolt fabricated from steel rod. Provide Type 40 insulation shield, secured by two 13mm (1/2 inch) galvanized steel bands, or preinsulated calcium silicate shield for insulated piping at each hanger.

.8 Supports for Piping Systems:

.1 Select hangers sized to encircle insulation on insulated piping.To protect insulation, provide Type 39 saddles for roller type supports or preinsulated calcium silicate shields. Provide Type 40 insulation shield or preinsulated calcium silicate shield at all other types of supports and hangers including those for preinsulated piping.

.9 Piping Systems (MSS SP 58):

.1 Standard clevis hanger: Type 1; provide locknut.
.2 Riser clamps: Type 8.
.3 Wall brackets: Types 31, 32 or 33.
.4 Roller supports: Type 41, 43, 44 and 46.
.5 Saddle support: Type 36, 37 or 38.
.6 Turnbuckle: Types 13 or 15. Preinsulate.
.7 U bolt clamp: Type 24.
.8 Copper Tube:

1 Hangers, clamps and other support material in contact with tubing shall be painted with copper colored epoxy paint, plastic coated or taped with non adhesive isolation tape to prevent electrolysis.

2 For vertical runs use epoxy painted or plastic coated riser clamps.

3 For supporting tube to strut: Provide epoxy painted pipe straps for copper tube or plastic inserted vibration isolation clamps.

.9 Insulated Lines:

1 Provide pre-insulated calcium silicate shields sized for copper tube.

.10 Supports for plastic or glass piping: As recommended by the pipe manufacturer with black rubber tape extending one inch beyond steel support or clamp.

.10 Piping with Vertical Expansion and Contraction:

.1 Movement up to 20 mm (3/4 inch): Type 51 or 52 variable spring unit with integral turn buckle and load indicator.

.2 Movement more than 20 mm (3/4 inch): Type 54 or 55 constant support unit with integral adjusting nut, turn buckle and travel position indicator.

1.30 **PIPE PENETRATIONS**

.1 Install sleeves during construction for other than blocked out floor openings for risers in mechanical bays.

.2 To prevent accidental liquid spills from passing to a lower level, provide the following:

.1 For sleeves: Extend sleeve 25 mm (one inch) above finished floor and provide sealant for watertight joint.

.2 For blocked out floor openings: Provide 40 mm (1 1/2 inch) angle set in silicone adhesive around opening.

.3 For drilled penetrations: Provide 40 mm (1 1/2 inch) angle ring or square set in silicone adhesive around penetration.

.3 Penetrations are not allowed through beams or ribs, but may be installed in concrete beam flanges. Any deviation from these requirements must receive prior approval of Consultant.

.4 Sheet Metal: Provide for pipe passing through floors, interior walls, and partitions, unless brass or steel pipe sleeves are specifically called for below.

.5 Cast Iron or Zinc Coated Pipe Sleeves: Provide for pipe passing through exterior walls below grade. Make space between sleeve and pipe watertight with a modular or link rubber seal. Seal shall be applied at both ends of sleeve.

.6 Galvanized Steel or an alternate Black Iron Pipe with asphalt coating Sleeves: Provide for pipe passing through concrete beam flanges, except where brass pipe sleeves are called for. Provide sleeve for pipe passing through floor of mechanical rooms. Except in mechanical rooms, connect sleeve with floor plate.

.7 Brass Pipe Sleeves: Provide for pipe passing through quarry tile, terrazzo or ceramic tile floors. Connect sleeve with floor plate.

.8 Sleeves are not required for wall hydrants for fire department connections or in drywall construction.

.9 Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation. Interior openings shall be caulked tight with fire stopping material and sealant to prevent the spread of fire, smoke, and gases.

1.31 **WALL, FLOOR AND CEILING PLATES**

.1 Material and Type: Chrome plated brass or chrome plated steel, one piece or split type with concealed hinge, with set screw for fastening to pipe, or sleeve. Use plates that fit tight around pipes, cover openings around pipes and cover the entire pipe sleeve projection.

.2 Thickness: Not less than 2.4 mm (3/32 inch) for floor plates. For wall and ceiling plates, not less than 0.64 mm (0.025-inch) for up to 80 mm (3 inch pipe), 0.89 mm (0.035-inch) for larger pipe.

.3 Locations: Use where pipe penetrates floors, walls and ceilings in exposed locations, in finished areas only. Use also where insulation ends on exposed water supply pipe drop from overhead. Provide a watertight joint in spaces where brass or steel pipe sleeves are specified.

1.32 PAINTING

.1 Apply at least one coat of corrosion resistant primer paint to supports, and equipment fabricated from ferrous metals.

.2 Touch-up paint all damaged equipment with products matching original finish in quality and appearance.

.3 Paint new sections of gas pipe with two coats of yellow outdoor grade paint.

.4 Paint all new shafts and bulkheads (where provided) with 2 coats of indoor paint (white).

1.33 DIELECTRIC COUPLINGS

.1 Provide wherever pipes of dissimilar metals are joined.

.2 Provide insulating unions for pipe sizes larger than 2" diam. and under; same for flanges of pipe sizes over 2" diam.

.3 Cast brass adapters may be used on domestic water systems and where approved by the Consultant.

.4 Provide rubber gaskets to prevent dissimilar metals contact.

1.34 INSTRUCTION OF OPERATING STAFF

.1 Supply certified personnel to instruct Board operating staff on operation of new mechanical equipment. Supply maintenance specialist personnel to instruct operating staff on maintenance and adjustment of mechanical equipment and any changes or modification in equipment made under terms of guarantee.

.2 Provide min. 4 hrs of instruction time at each building during regular work hours prior to acceptance and turn-over to operating staff for regular operation.

.3 Use operation and maintenance data manual for instruction purposes. On completion of instruction, turn manuals over to the Consultant.

.4 Scheduling of the timing for the training of the operating staff shall be arranged 10 days prior to the completion of the project.

.5 For training on controls, refer to section 15900

1.35 **MAINTENANCE MANUALS**

.1 Provide minimum of four copies of Mechanical Maintenance Manuals, in accordance to the following:

.1 Mechanical Maintenance Manuals to be delivered to the Consultant's office 10 days prior to the substantial completion of the Contract.

.2 Manuals to be bound in a hard cover neatly labeled: "OPERATING AND MAINTENANCE INSTRUCTIONS".

.3 The Maintenance Manuals shall be divided into sections with neatly labeled and tabbed dividers between each section. The sections to be included in the manual are:

.1 Section I - General.
.2 Section II - Air handling and A/C Equipment and Accessories.
.3 Section III - Automatic Controls
.4 Section IV - Air and Water Balancing, ESA inspection certificate for all new electrical work, Equipment start-up reports
.5 Section V - Mechanical/Electrical as-built drawings in CAD and PDF.

.4 The following information shall be contained within the sections:

.1 SECTION I: A list giving name, address and telephone number of the Consultant, Engineers, General Contractor, Mechanical Trade and Controls Trade. Written guarantees for the Mechanical Systems. Equipment lists and certificates shall be provided - certificates shall be signed and sealed by the appropriate suppliers.

.2 SECTION II: A copy of all pressure tests and operational tests. A list giving name, address and telephone number of all suppliers. Details of chemical treatment equipment and substances. A copy of all reviewed Shop Drawings for all mechanical equipment and ancillary devices, Copies of warranties from equipment manufacturer.

.3 SECTION III: Complete Control Diagrams, Wiring Diagrams and description of Control system and the functioning sequence of the system. Also refer to section 15900.

.4 SECTION IV: For balancing reports and formats, refer to section 15015 of these specifications.

1.36 **CONCRETE**

.1 All concrete work required to complete this project, wether shown on the drawings or not, shall be the Contractor's responsibility.

.2 Refer to this specification section for requirements for housekeeping pad.

1.37 **METALS**

.1 All steel construction required for the completion of this project, wether shown on the drawings or not, shall be the Contractor's responsibility.

1.38 **CUTTING, PATCHING, ROOFING AND X-RAY**

.1 All cutting, patching, roofing and X-Rays required for the completion of this project wether shown on the drawings or not, shall be the Contractor's responsibility. The cutting and patching work shall be performed in accordance with the following:

.1 All cutting and patching shall be done by the trades specializing in the materials to be cut.

.2 All flashing and equipment supports on the roof shall be done in strict accordance with the Board standards by Board-approved roofing contractors only.

.2 All work related to adjust millwork and other furniture in order to accommodate the new size of unit ventilators is included.

.3 All work required to modify the existing wall openings to accommodate the size of the new grilles and louvers serving the unit ventilators shall be included; the replacement of all louvers under the existing windows is included.

.4 All work required to paint or repair sections of the walls and floor so required due to different footprint of the new unit ventilators is included.

.5 Should any cutting, roofing and/or repairing of finished surfaces be required, the Sub-trade contractor for the Contractor shall employ the particular trades engaged on the site for this type of work to do such cutting and/or repairing. Obtain the approval of the Consultant before doing any cutting. In the event that tradesmen required for particular cutting and/or repairing are not already on the site, bring to the site tradesmen to do this work.

.6 Supporting members of any floor, wall or the building structure shall be cut only in such a location and manner as approved by the Consultant.

.7 Where slabs in the portions of the building which are existing must be saw-cut or core drilled, all locations shall be x-rayed prior to saw-cutting or core-drilling. All x-raying shall be done by personnel qualified in the use of the type of equipment required to x-ray the saw-cuts shall be permitted to perform this work on the site. No allowance will

be made later for expenses incurred through the failure of performing these x-rays.

1.39 MECHANICAL PROJECT COMPLETION

.1 10 (ten) days prior to substantial performance of work obtain documentation and/or prepare certification of the following items and submit them to the Board's representative.

.1 All inspection certificates.
.2 Guarantee certificates as called for under "Warranty".
.3 Record drawings.
.4 Operating and Maintenance Manuals.
.5 Test certifications as called for under "Testing".
.6 Provide a signed statement to the effect that all tests for mechanical systems and equipment have been completely carried out in the Trade Sections of these Specifications and to the manufacturer's recommendations, and in accordance with the requirements of all authorities having jurisdiction.

1.40 PERFORMANCE TESTS AND EQUIPMENT START-UP

.1 After all equipment has been installed, adjusted, balanced and started up, subject equipment to a series of performance tests, as soon as conditions permit.

.2 The timing of the tests shall be arranged to suit the convenience of the Consultant, and the manner and duration shall be as the Consultant deems necessary. Record the daily start and stop times, operating hours and functions performed. Ensure that the performance tests are witnessed by the Consultant.

.3 All major equipment including but not limited to air handlers and heat rejection equipment are to be inspected by the manufacturer to ensure that the equipment has been installed in accordance with their recommendations.

.4 Operate equipment under varying load conditions, demonstrate start-up sequence, normal shutdown, simulated emergency shutdown, operation of temperature, etc., and safety controls. Operate switches and electrical devices for correct wiring sequences. Adjust components to achieve a proper functional relationship among all the components of all the systems. Repeat these functions as many times as deemed necessary by the Consultant to achieve reliable operation.

.5 Repair defects and repeat tests as necessary. During test maintain lubrication schedule, set, align and tension drives.

.6 At the successful completion of Performance Tests and all testing and balancing, make the systems ready for final inspection and subsequent acceptance of the Board. Replace and clean filters, flush out lines and equipment, remove and clean strainers, fill liquid systems and purge air.

.7 Conduct tests to demonstrate operation and ability to meet requirements of all equipment and freedom from undue noise and vibration at the time of final inspection,

having ensured that it has previously been subjected to Performance Tests.

Part 1 - General

1.1 REFERENCES

.1 ASTM A 123/A 123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

.2 ASTM A 153/A 153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

.3 ASTM D 1929 - Standard Test Method for Determining Ignition Temperature of Plastics

.4 MSS SP-58 - Pipe Hangers and Supports -- Materials, Design and Manufacture; Manufacturers Standardization Society of the Valve and Fittings Industry

.5 MSS SP-69 - Pipe Hangers and Supports -- Selection and Application; Manufacturers Standardization Society of the Valve and Fittings Industry

1.2 SYSTEM DESCRIPTION

.1 Support piping and conduits on roof with an engineered, prefabricated system designed for installation without roof penetrations, flashings, or damage to the roofing material. The system shall consist of bases, made of high density, polypropylene plastics with UV Protection, a HDG structural steel frame, and suitable pipe hangers for the application. Nuts, threaded rods and washers shall be HDG, spring nuts, and bolts for spring nuts, will be electro-plated. System shall be custom designed to fit piping and conduit to be installed, and the actual conditions of service.

1.3 SUBMITTALS

.1 Submit shop drawings in accordance with the requirements of section 15010.

.2 Product Data: Submit for all products proposed for use, describing physical characteristics and method of installation.

.3 Show installation layout, sizes of units, and details of installation.

.4 Verification Samples: Upon request by consultant, supply actual samples of bases, each type of support, hanger, and fasteners; and not less than 12 inches (300 mm) of framing members.

1.4 QUALITY ASSURANCE

.1 Pre-Installation Meeting: After approval of submittals, but before beginning installation, conduct a meeting at the project site attended by the Consultant, Contractor. Purpose of meeting is to describe in detail the installation process and to establish agreement, coordination, and responsibilities.

1.5 DELIVERY, STORAGE, AND HANDLING

.1 Deliver all materials to project site in manufacturer's original packaging, marked with

manufacturer's name, product model names and catalog numbers, identification numbers, and other related information.

.2 Store materials under cover until needed for installation.

1.6 **WARRANTY**

.1 Warranty: Five (5) year limited warranty to repair or replace, at our option, any products we find to be structurally defective in material or workmanship.

1.7 **STANDARD OF ACCEPTANCE**

.1 Portable Pipe Hangers, Miro Industries

PART2 - PRODUCTS

2.1 **GENERAL**

.1 Support pipes, conduit, cable trays, and ducting, a minimum of 6 inches (150 mm) above roof surface.

2.2 **MATERIALS**

.1 Portable Support System:

.1 Engineered, portable system specifically designed for installation without the need for roof penetrations, or flashings, and without causing damage to the roofing membrane.

.2 Design system using high density, high impact polypropylene bases with carbon black, anti-oxidants for UV protection, and steel framing of 1-5/8 inch (41 mm) B22TH or 1-7/8 inch (48 mm) BTS22TH for support.

.3 Custom design system to fit piping, conduits, equipment, or walkways to be installed and actual conditions of service and loading.

.2 Piping Supports:

.1 Provide suitable hangers and supports

.3 Duct and Equipment Supports:

.1 Factory fabricated to support exact duct sizes and equipment to be installed.

.4 Steel Framing:

.1 Channel Types: 1-5/8 inch (41.3 mm) B22TH or 1-7/8 inch (47.6 mm) BTS22H, as required for loading conditions.

.2 Thickness: 12 gage (2.7 mm).

.3 Form: Roll-formed 3-sided or tubular channel, perforated with 9/16 inch (14.3 mm) holes at 1-7/8 inch (47.6mm) centers on three sides.

.4 Finish: Hot dip galvanize in accordance with ASTM A 123 after fabrication, free of roughness, whiskers, unsightly spangles, icicles, runs, barbs, sags, droplets, and other surface blemishes. Do not use tubing or tube steel.

.5 Pipe Supports and Hangers:

.1 Conform to MSS SP-58 and MSS SP-69

.2 Fabricated of carbon steel where framing is carbon steel; fabricated of stainless steel where framing is stainless steel; finished same as framing.

.3 Sizes 2½ inch (63 mm) and smaller: Single roller supports for piping subject to expansion and contraction; 3-sided channels and pipe clamps.

.4 Sizes 3 inch (76 mm) and larger: Rollers, clevis hangers, or band hangers, to allow for expansion and contraction without movement of the bases or framing.

.6 Accessories:

.1 Clamps, bolts, nuts, washers, and other devices as required for a complete system.

.2 Carbon Steel: Hot-dip galvanized in accordance with ASTM A 153/A 153M.

PART3 - EXECUTION

3.1 EXAMINATION

.1 Verify that roofing system is smooth, flat, and ready to receive work of this section.

.2 Verify that roof surface temperature is at minimum 60°F (15.5°C) for proper adhesive performance.

3.2 PREPARATION

.1 Clean surfaces of roof in areas to receive portable support bases.

.2 Sweep loose gravel from gravel surfaced roofs.

.3 Remove dirt, dust, oils, and other foreign materials.

.4 Use care in handling portable support system components during installation, to avoid damage to roofing, flashing, equipment, or related materials.

3.3 INSTALLATION

.1 Pipe, Conduit, Cables

.1 Locate bases and support framing as indicated on drawings and as specified herein. Provide complete and adequate support of all piping, ducting, and conduit; whether or not all required devices are shown.

.2 The use of wood for supporting piping is not permitted.

.3 Provide support spacing so deflection of piping does not exceed 1/240 of span.

.4 Install framing at spacing indicated, but in no case at greater than 10 feet (3 m) on center.

.5 Accurately locate and align bases.

.6 Consult manufacturer of existing or new roofing system as to the type of isolation pads required between the roof and base.

.7 Set isolation pads in adhesive, if required by manufacturer's instructions.

.8 Place bases on isolation pads.

.9 Adhere or mechanically attach, if required by code.

.10 Where applicable, replace gravel around bases.

.11 Set framing posts into bases and assemble framing structure as indicated.

.12 Use galvanized fasteners for galvanized framing and stainless steel fasteners for stainless steel framing.

.2 Duct Support Systems

.1 Locate bases and support framing as indicated on drawings and as specified herein. Provide complete and adequate support of all piping, ducting, and conduit, whether or not all required devices are shown.

.2 Accurately locate and align bases.

.3 Consult manufacturer of existing or new roofing system as to the type of isolation pads required between the roof and base.

.4 Set isolation pads in adhesive, if required by manufacturer's instructions.

.5 Place bases on isolation pads.

.6 Adhere or mechanically attach, if required by code.

.7 Where applicable, replace gravel around bases.

.8 Place pre-assembled support onto bases, attaching framing post to base bracket with ½ inch bolts provided, and adjust as needed. Support shall be adjustable to maintain existing elevation and slope.

.9 Use galvanized fasteners for galvanized framing and stainless steel fasteners for stainless steel framing.

3.4 FIELD QUALITY CONTROL

.1 Provide a factory-trained representative of the manufacturer to visit the site while the work is in progress to assure that the installation conforms to the manufacturers design and installation requirements.

3.5 CLEANING AND PROTECTION

.1 Remove all packaging, unused fasteners, adhesive and other installation materials from the project site.

.2 Remove adhesive from exposed surfaces of supports and bases, and leave the work area in clean condition.

.3 Provide protection as required, leaving the work area in undamaged condition at the time of completion of work.

1 General

1.1 GENERAL

.1 This section of the specification shall be read in conjunction with and be governed by the requirements of Section 15010.
.2 The scope of work in this section covers the entire system associated with the rooftop equipment to be replaced, including ductwork, booster coils, terminal diffusers.

1.2 DESCRIPTION

.1 Testing, adjusting, and balancing (TAB) of heating, ventilating and air conditioning (HVAC) systems. TAB includes the following:

.1 Systems Inspection report.
.2 Balancing air and water distribution systems; adjustment of total system to provide design performance;
.3 Recording and reporting results.

1.3 DEFINITIONS

.1 TAB: Testing, Adjusting and Balancing; the process of checking and adjusting HVAC systems to meet design objectives.

.2 AABC: Associated Air Balance Council.

.3 NEBB (National Environmental Balancing Bureau)

.4 Hydronic Systems: Includes heating hot water, domestic hot water recirculation, chilled water, condenser water, and glycol water systems, as applicable to the project.

.5 Air Handling Systems: Includes all central and distributed air handling equipment that provide outside air, supply air, return air, exhaust air and relief air to and from the building, as applicable to the project.

.6 Air distribution systems: Includes all grilles, diffusers, terminal units (by pass/VAV).

.7 Flow rate tolerance: The allowable percentage variation, minus to plus, of actual flow rate from values (design) in the contract documents.

1.4 QUALITY ASSURANCE

.1 Qualifications:

.1 TAB Agency: The TAB agency shall be a subcontractor of the Mechanical Contractor and shall report to and be paid by the Mechanical Contractor.

.2 The TAB agency shall be either a certified member of AABC or NEBB to perform TAB service for HVAC and water balancing equipment. The certification shall be maintained for the entire duration of duties specified herein. If, for any reason, the agency loses subject certification during this period, the General Contractor shall immediately notify

the Consultant and the Owner and submit another TAB firm for approval.

.3 TAB Specialist: The TAB specialist shall be either a member of AABC or NEBB or an experienced technician of the Agency.

.2 TAB Agency shall be identified by the Mechanical Contractor within 60 days after the award of the contract.

.3 The TAB specialist will be coordinating, scheduling and reporting all TAB work and related activities and will provide necessary information as required by the Consultant. The responsibilities would specifically include:

.1 Shall directly supervise all TAB work.
.2 Shall sign the TAB reports that bear the seal of the TAB Agency. The reports shall be accompanied by report forms and schematic drawings required by the TAB standard, AABC.
.3 Would follow all TAB work through its satisfactory completion.
.4 Shall provide final markings of settings of all HVAC adjustment devices.
.5 Permanently mark location of duct test ports.

.4 Test Equipment Criteria: The instrumentation shall meet the accuracy/calibration requirements established by AABC National Standards and or by the instrument manufacturer.

.5 Tab Criteria:

.1 Air Filter resistance during tests, artificially imposed if necessary, shall be at least 90 percent of final values for pre-filters and after-filters.

.2 Flow rate tolerance:

.1 Air handling unit and all other fans, cubic meters/min (cubic feet per minute): Minus 5% to plus l0%.
.2 Grilles, diffusers and air terminal units (maximum values): -5% to +l0%.
.3 Exhaust hoods/cabinets: 0 % to plus l0 %.
.4 Minimum outside air: 0 % to plus 10 %.
.5 Individual room air outlets and inlets, and air flow rates not mentioned above: Minus 5 % to plus l0 % except if the air to a space is 100 CFM or less the tolerance would be 0 to plus 5 %.
.6 Heating hot water pumps and hot water coils: Minus 5 % to plus 5 %.
.7 Heating hot water convectors, forced flow heaters, unit heaters: Minus 5 % to plus 5 %.
.8 Chilled water and condenser water pumps: minus 5%t to plus 5 %.
.9 Chilled water coils: minus 5 % to plus 5 %.

1.5 SUBMITTALS

.1 Submit Following for Review to the Consultant:

.1 Systems inspection report on equipment and installation for conformance with design.

.2 Duct Air Leakage Test Report.

.3 Final TAB reports covering flow balance and adjustments, performance tests.

.4 Include in final reports uncorrected installation deficiencies noted during TAB and applicable explanatory comments on test results that differ from design requirements.

1.6 **APPLICABLE PUBLICATIONS**

.1 The following publications form a part of this specification to the extent indicated by the reference thereto. In text the publications are referenced to by the acronym of the organization.

.2 American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE): HVAC Applications ASHRAE Handbook, Testing, Adjusting, and Balancing

.3 Associated Air Balance Council (AABC): AABC National Standards for Total System Balance

.4 Sheet Metal and Air Conditioning Contractors National Association (SMACNA): HVAC SYSTEMS Testing, Adjusting and Balancing

2 Products

2.1 **PLUGS**

.1 Provide plastic plugs to seal holes drilled in ductwork for test purposes.

2.2 **INSULATION REPAIR MATERIAL**

.1 Coordinate with the mechanical Contractor the TAB activity such that it does take place before the insulation is installed on ductwork and piping.

.2 In the absence of such coordination, the mechanical contractor shall be responsible for the repair to the ductwork and or piping insulation removed for TAB purposes, including the integrity of the vapor barrier material and the insulation jacket.

3 Execution

3.1 **GENERAL**

.1 Obtain applicable contract documents and copies of approved submittals for HVAC equipment and automatic control systems.

3.2 **SYSTEMS INSPECTION REPORT**

.1 Inspect equipment and installation for conformance with design.

.2 The inspection and report is to be done after air distribution equipment is on site and duct installation has begun, but well in advance of performance testing and balancing work. The purpose of the inspection is to identify and report deviations from design and ensure that

systems will be ready for TAB at the appropriate time.

.3 Verify that all items such as ductwork piping, ports, terminals, connectors, etc., that is required for TAB are installed. Provide a report to the Consultant.

.4 Reports: Follow check list format developed by AABC or SMACNA, supplemented by narrative comments, with emphasis on air handling units and fans. Check for conformance with submittals. Verify that diffuser and register sizes are correct. Check air terminal unit installation including their duct sizes and routing.

3.3 TAB REPORT

.1 Format to be in accordance with referenced standard listed above, but using design drawing units.

.2 Produce "as-built" full system schematics. Use as-built drawings for reference.

.3 Submit 1 copy of preliminary TAB reports, each in "D" ring binders, complete with index tabs for verification and approval of Consultant.

.4 Submit copies of final TAB reports after approval by the Consultant, to be incorporated into the Maintenance and Operations Manual, as indicated in section 15010.

3.4 PROCEDURES

.1 Tab shall be performed in accordance with the requirement of the Standard under which TAB agency is certified.

.2 Start final TAB only when building is essentially completed, including:

.1 Installation of ceilings, doors, windows and other construction affecting TAB.
.2 Application of sealing, caulking and weather-stripping.

.3 Normal operation of mechanical systems affecting TAB.

.3 General: During TAB all related system components shall be in full operation. Fan and pump rotation, motor loads and equipment vibration shall be checked and corrected as necessary before proceeding with TAB. Set controls and/or block off parts of distribution systems to simulate design operation of variable volume air or water systems for test and balance work.

.4 Mechanical Contractor to allow for the supply and installation of new sheaves as required for the proper balance of the fans and trim or replace impellers for proper balancing of the pumps.

3.5 AIR BALANCE AND EQUIPMENT TEST:

.1 Include all air handling units, fans, HRV, room diffusers/outlets/inlets, elevator machine AC units, as applicable to this project.

.2 Artificially load air filters by partial blanking to produce air pressure drop of at least 90

percent of the design final pressure drop.

.3 Adjust fan speeds to provide design air flow.

.4 Test and balance systems in all specified modes of operation, including variable volume, economizer, and fire emergency modes. Verify that dampers and other controls function properly.

.5 Record final measurements for air handling equipment performance data sheets.

.6 Parameters to be Measured (where applicable)

- .1 Air Flow
- .2 Air velocity.
- .3 Static pressure.
- .4 Velocity pressure.
- .5 Temperature:
  - .1 Wet bulb.
  - .2 Dry bulb.
- .6 Cross sectional area.
- .7 Fans RPM
- .8 Electrical power:
  - .1 Voltage
  - .2 Current draw.

.7 Locations of Measurements

- .1 Inlet and outlet of each
  - .1 Fan.
  - .2 Coil.
  - .3 Filter.
  - .4 Balancing damper.
  - .5 Other auxiliary equipment.
- .2 Main ducts.
- .3 Main branch ducts.
- .4 Sub-branch ducts.
- .5 Each supply, exhaust and return air inlet and outlet.
- .6 Before and after the silencers.

3.6 WATER BALANCE AND EQUIPMENT TEST:

.1 Include all radiation equipment, circulating pumps, boilers and condensers, as applicable to this project.

.2 Adjust flow rates for equipment to the values indicated on the drawings and schedules. Set balancing valves and circuit setters to the values on indicated on the equipment schedules

.3 Record final measurements for hydronic equipment on performance data sheets. Include entering and leaving water temperatures for heating coils, and for heat exchangers. Include entering and leaving air temperatures (DB/WB for cooling coils) for air handling units and reheat coils. Make air and water temperature measurements at the same time.

.4 Parameters to be Measured (where applicable)

.1 Water/Glycol Flow (as applicable to the project)
.2 Pressure.
.3 Temperature.
.4 Specific gravity.
.5 Pumps RPM
.6 Electrical power:
.1 Voltage
.2 Current draw.

.5 Locations of Measurements

.1 Inlet and outlet of each
.1 Pump.
.2 Coil.
.3 Boiler.
.4 Balancing valve.
.5 Automatic control valves
.6 Chiller.

3.7 VERIFICATION:

.1 Reported measurements shall be subject to verification by Consultant. Provide instrumentation and manpower to verify results of up to 30 % of all reported measurements. Number and location of verified measurements to be at discretion of Consultant.

.2 Bear costs to repeat TAB, as required, to satisfaction of Consultant.

3.8 MARKING OF SETTINGS

.1 Following approval of TAB final Report, the setting of all HVAC adjustment devices including balancing valves, splitters and dampers shall be permanently marked by the TAB Specialist so that adjustment can be restored if disturbed at any time. Style and colors used for markings shall be coordinated with the Consultant.

3.9 IDENTIFICATION OF TEST PORTS

.1 The TAB Specialist shall permanently and legibly identify the location points of duct test ports. If the ductwork has exterior insulation, the identification shall be made on the exterior side of the insulation. All penetrations through ductwork and ductwork insulation shall be sealed to prevent air leaks and maintain integrity of vapor barrier.

- END -

1 General

1.1 GENERAL

.1 Section Includes:

.1 Mechanical Equipment and HVAC Controls Identification.

1.2 DEFINITIONS

.1 Exposed Areas

.1 Finished areas and other areas used by personnel in normal use of building, such as equipment rooms and storage rooms.

.2 Concealed Areas

.1 Duct or pipe tunnels, duct or pipe chases, spaces above accessible ceilings, and crawl spaces.

2 Products

2.1 STANDARD OF ACCEPTANCE

.1 W. H. Brady Co. catalogue numbers are used as a basis of identification.

.2 Stock catalogue numbers are listed in these specifications. Subcontractor is responsible to review schedules and provide required markers. In some instances, "non-stock" markers (special) may be required.

2.2 MANUFACTURER'S NAMEPLATES

.1 Manufacturer's nameplates:

.1 Provide metal nameplate on each piece of equipment, mechanically fastened with raised or recessed letters.
.2 Provide Underwriters' Laboratories or CSA registration plates, as required by respective agency.
.3 Manufacturers nameplate to indicate size, equipment model, manufacturer's name, serial number, voltage, cycle, phase and power of motors.
.4 Locate nameplates so that they are easily read. Do not insulate or paint over plates.

2.3 CONTROLS IDENTIFICATION

.1 Refer to section 15900

2.4 EQUIPMENT IDENTIFICATION

.1 Labelling shall be furnished and installed by the contractor

.2 Engraved signs shall be dark letters on light background.

.3 Identify mechanical equipment and HVAC controls, e.g., air handling units, pumps, heat transfer equipment, water treatment devices, controls instruments, stationary tanks/containers, and similar items, with nameplates or tags.

.4 Provide engraved nameplates made of rigid plastic laminate in which colored top and bottom layers of the material are thermoset with a contrasting color core. Minimum thickness 0.062 inch.

.5 Size: min. 1" x 3".

.6 Material Color: White background/ black lettering.

.7 Manufacturer: Brady, No. B-1

.8 Provide lettering as follows:

.1 Size: 10 point minimum
.2 Spacing: 1/4 inch from top, 1/8 inch from bottom, 1/16 inch between lines.
.3 Provide nameplate with component nomenclature as noted in the Equipment Schedules. Coordinate with the controls sub-contractor.

.9 As a minimum, identify the system, e.g., HVAC (heating, ventilating, and air conditioning), the component, e.g., FGF (furnace, gas fired), and the sequence number.

3 Execution

3.1 **PREPARATION**

.1 Degrease and clean surfaces to receive adhesive for identification materials.

- END -

1 - General

1.1 GENERAL

.1 This section of the specification shall be read in conjunction with and be governed by the requirements of Section 15010.

1.2 SHOP DRAWINGS

.1 Submit shop drawings in accordance with Section 15010.

.2 Provide separate shop drawings for each isolated system complete with performance and product data.

.3 Submit type of isolator, size, height when uncompressed and maximum allowable static deflection weight of all isolated equipment, loads on each isolator and static deflection of each isolator under the specific design load.

.4 Submit marked up plans indicating all locations where pipes are to be isolated in mechanical rooms and as specified.

2 - Products

2.1 GENERAL

.1 Vibration isolator sizes and layout shall be determined by the vibration isolator supplier.

.2 Elastomeric elements that will be exposed to temperatures below freezing shall be fabricated from natural rubber instead of neoprene.

.3 All isolators to be installed outdoors or exposed to weather shall be hot dipped galvanized and shall be furnished with neoprene mounting sleeves for hold-down bolts to prevent any metal to metal contact.

.4 Standard of Acceptance: Kinetics Noise Control, Vibro-Acoustics.

2.2 FLEXIBLE DUCT CONNECTORS

.1 Flexible Connections

.1 Where duct connections are made to fans and air handling units (not internally isolated), install a non combustible flexible connection of 822 g (29 ounce) neoprene coated fiberglass fabric approximately 150 mm (6 inches) wide. For connections exposed to sun and weather provide hypalon coating in lieu of neoprene. Burning characteristics shall conform to NFPA 90A. Securely fasten flexible connections to round ducts with stainless steel or zinc coated iron draw bands with worm gear fastener. For rectangular connections, crimp fabric to sheet metal and fasten sheet metal to ducts by screws 50 mm (2 inches) on center. Fabric shall not be stressed other than by air pressure. Allow at least 25 mm (one inch) slack during operation to insure that no vibration is transmitted.

.2 Length of connection: 6"

.3 Minimum distance between metal parts when system in operation: 3"

.4 Install in accordance with recommendations of SMACNA.

2.3 ELASTOMERIC PADS (only if sleepers are present)

.1 Neoprene waffle or ribbed; 9mm minimum thick; 50 durometer; maximum loading 350 kPa. Mason type W

.1 Application: air handling unit pads (between sleepers and unit frame)

3 - Execution

3.1 INSTALLATION

.1 Provide vibration isolation for new equipment as noted in the specification, listed in the schedule and shown on the drawings.

.2 Install vibration isolation equipment in accordance with manufacturers instructions and adjust mountings to level equipment.

.3 All final wiring connections to the roof-top mechanical equipment shall be made with liquid tight flexible conduit; minimum conduit length: 2 ft.

.4 Provide suitable supports for all equipment which does not have a frame with adequate rigidity.

.5 There shall be a minimum of 4" clearance between isolated equipment and the walls, ceiling, floors, columns and any other equipment not installed on vibration isolators.

.6 Piping, ductwork, conduit or mechanical equipment shall not be hung from or supported on other equipment, pipes or ductwork installed on vibration isolators. It shall be supported on or suspended from building structure**.**

- END -

1. GENERAL

1.1 RELATED DOCUMENTS

.1 Drawings and general provisions of the Bid Documents, apply to this Section.

1.2 SUMMARY

.1 Perform all Work required to provide and install ductwork insulation and jackets indicated by the Bid Documents with supplementary items necessary for proper installation.

1.3 REFERENCE STANDARDS

.1 The latest published edition of a reference shall be applicable to this Project unless identified by a specific edition date.

.2 All materials, installation and workmanship shall comply with the applicable requirements and standards addressed within the following references:

.1 ASTM B209 - Aluminum and Aluminum-Alloy Sheet and Plate.

.2 ASTM C168 - Terminology Relating to Thermal Insulation Materials.

.3 ASTM C518 - Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.

.4 ASTM C553 - Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.

.5 ASTM C612 - Mineral Fiber Block and Board Thermal Insulation.

.6 ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).

.7 ASTM C1104 - Standard Test Method for Determining the Water Vapor Sorption of Unfaced Mineral Fiber Insulation.

.8 ASTM C1290 - Standard Specification for Flexible Fibrous Glass Blanket Insulation Used to Externally Insulate HVAC Ducts.

.9 ASTM C1136 - Standard Specification for Flexible, Low Permeance Vapor Retarders for Thermal Insulation.

.10 ASTM C1338 - Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings.

.11 ASTM E84 - Surface Burning Characteristics of Building Materials.

.12 ASTM E96 - Water Vapor Transmission of Materials.

.13 ASTM E119 - Standard Test Methods for Fire Tests of Building Construction and Materials.

.14 ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.

.15 NFPA 255 - Surface Burning Characteristics of Building Materials.

.16 SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

.17 ULC 181 - Standard for Factory-Made Air Ducts and Air Connectors.

.18 ULC 723 - Surface Burning Characteristics of Building Materials.

.19 ASTM E2336 - Standard for Grease Ducts.

.20 ASTM D5590 - - Standard Test Method for Determining the Resistance of Paint Films and Related Coatings to Fungal Defacement by Accelerated Four-Week Agar Plate Assay

1.4 QUALITY ASSURANCE

.1 All ductwork requiring insulation shall be insulated as specified herein and as required for a complete system. In each case, the insulation shall be equivalent to that specified and materials applied and finished as described in these Specifications.

.2 All insulation, jacket, adhesives, mastics, sealers, etc., utilized in the fabrication of these systems shall meet NFPA requirements for fire resistant ratings (maximum of 25 flame spread and 50 smoke developed ratings) and shall be approved by the insulation manufacturer for guaranteed performances when incorporated into their insulation system, unless a specific product is specified for a specific application and is stated as an exception to this requirement.

.3 Certificates to this effect shall be submitted along with Contractor's submittal data for this Section of the Specifications. No material may be used that, when tested by the ASTM E84-89 test method, is found to melt, drip or delaminate to such a degree that the continuity of the flame front is destroyed, thereby resulting in an artificially low flame spread rating.

.4 All insulation shall be applied by mechanics skilled in this particular Work and regularly engaged in such occupation.

.5 All insulation shall be applied in strict accordance with these Specifications and with factory printed recommendations on items not herein mentioned. Unsightly, inadequate, or sloppy Work will not be acceptable.

1.5 SUBMITTALS

.1 Product Data:

.1 Provide product description, list of materials, "k" value, "R" value, mean temperature range, and thickness for each service and location.

.2 Record Documents:

.1 Submit under provisions of section 15010.

.3 Operation and Maintenance Data:

.1 Samples: When requested, submit three (3) samples of any representative size illustrating each insulation type.

.2 Manufacturer's Installation Instructions: Indicate procedures that ensure acceptable standards will be achieved. Submit certificates to this effect.

1.6 DELIVERY, STORAGE AND HANDLING

.1 Deliver, store, protect, and handle products to the Project Site under provisions of section 15010

.2 Deliver materials to Site in original factory packaging, labeled with manufacturer's identification including product thermal ratings and thickness.

.3 Store insulation in original wrapping and protect from weather and construction traffic. Protect insulation against dirt, water, chemical, and mechanical damage.

.4 Maintain ambient temperatures and conditions required by manufacturers of adhesives, mastics and insulation cements.

2. PRODUCTS

2.1 GENERAL

.1 All materials shall meet or exceed all applicable referenced standards, provincial and local requirements, and conform to codes and ordinances of authorities having jurisdiction.

2.2 MANUFACTURERS

.1 Johns Manville Corporation.

.2 Knauf Corporation.

.3 Owens-Corning.

.4 Armacell North America.

.5 3M Fire Protection Products (Fire Barrier Duct Wrap 615+)

2.3 INSULATION MATERIALS

.1 Type D1:

.1 Flexible glass fiber; ASTM C553 and ASTM C1290; commercial grade; 'k' value of 0.25 at 75 degrees F; 1.5 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.

.2 Type D2:

.1 Rigid glass fiber; ASTM C612, Class 1; 'k' value of 0.23 at 75 degrees F; 3.0 lb/cu ft minimum density; 0.002 inch foil scrim kraft facing for air ducts.

.3 Type D3:

.1 Fire Rated Grease Duct Insulation (High Temperature Flexible Blanket); 1½ inch thick refractory grade fibrous fire barrier material with minimum service temperature design of 2,000 degrees F; aluminum foil laminated on both sides; with a minimum 'k' value of 0.25 and a minimum density of 6 lbs/cu ft; containing no asbestos. Listed by a nationally recognized testing laboratory (NRTL) UL to meet ASTM E 2336, ASTM E119, and with flame spread/smoke minimum rating of 25 / 50 when tested as per ASTM E84/UL 723.

.4 Type D4:

.1 Outdoor Duct Insulation (Closed Cell Flexible Elastomeric Insulation - Aerocell EPDM)); 1 inch thick material that has a service temperature range from –60 degrees F to 180 degrees F. This outdoor duct insulation meets ASTM C 177 or C 518 and shall have minimum 'k' value of 0.27 Btu-in. / hr-ft2- degrees F at minimum density measurement of 3 lb/cu ft.

.2 The insulation and outside surface must be protected with a white Thermo Plastic Rubber Membrane formulated to:

a. Be resistant to UV, and ozone, acid rain, and physical elements produced from outdoor weather per ASTM E 96 Procedure A.

b. Have aflame spread rating of 25 or less and a smoke developed rating of 50 or less when tested in accordance with the test method for surface burning in ASTM E 84.

c. Show no evidence of continued erosion, delaminating, cracking, flaking, or peeling when tested in accordance with the test method for erosion resistance in UL181. Be resistant to mold growth resistance, ASTM G 21/C 1338 resistant to fungi, and resistant to bacteria growth per ASTM G 22.

d. Jacket

1) Top layer: Stucco-embossed, UV-resistant aluminum weathering surface
2) Middle Layer: Double layer of high-density polyethylene reinforcement
3) Bottom Layer: Uniform layer of rubberized asphalt adhesive, protected by disposable silicone release paper
4) Heat Aging, ASTM D 794: No visible blistering or deterioration.
5) Tear Resistance, ASTM D 1424, Average: 660 grams.
6) Elongation, ASTM D 412, Minimum: 450 percent.
7) Low Temperature Flexibility, 1,000,000 Cycles at -10 Degrees F, 1,200 Cycles at -20 Degrees F: No cracking.
8) Water Vapor Transmission, ASTM E 96: 0.009 perms.
9) Flame Spread Index, ASTM E 84: 0.
10) Smoke Density Index, ASTM E 84: 5.
11) Wind-Driven Rain, SFBC TAS-110-95, 100 mph: No leakage or failure.
12) UV Stability: Excellent

13) Acceptable manufacturer: Polyguard (Alumaguard All Weather), MFM (FlexClad)

2.4 INSULATION ACCESSORIES

.1 Adhesives: Waterproof vapor barrier type, meeting requirements of ASTM C916; Childers CP-82 or Foster 85-20/85-60.

.2 Weather Barrier: Breather Mastic: Childers CP-10/CP-11 or Foster 46-50 White..

.3 Vapor Barrier Coating: Permeance - ASTM E 96, Procedure B, 0.08 perm or less at 45-mil dry film thickness, tested at 100F and 50%RH; Foster 30-65 or Childers CP-34

.1 When higher humidity levels may be of concern, only specify the following fungus/mold resistant coating: Foster 30-80 AF (anti fungal). Coating must meet ASTM D 5590 with 0 growth rating**

.4 Reinforcing Mesh: 10x10 or 9x8 glass mesh; Foster Mast a Fab or Childers #10

.5 Jacket: Pre-sized glass cloth, minimum 7.8 oz/sq yd.

.6 Type D3 Insulation Adhesive: Fire resistive to ASTM E84, Childers CP-82 or Foster 85-20.

.7 Impale Anchors: Galvanized steel, 12 gage self-adhesive pad.

.8 Joint Tape: Glass fiber cloth, open mesh.

.9 Tie Wire and Wire Mesh: Annealed steel, 16 gage.

.10 Stainless Steel Banding: 3/4-inch wide, minimum 22 gage, 304 stainless.

.11 Armaflex 520, 520 BLV, or Foster 85-75 contact adhesive.

.12 Armatuff 25 white seal seam tape.

3. EXECUTION

3.1 PREPARATION

.1 Verify that ductwork has been tested before applying insulation materials.

.2 Verify that surfaces are clean, foreign material removed, and dry.

.3 Maintain required ambient temperature during and after installation for a minimum period of 24 hours.

3.2 INSTALLATION

.1 Installation shall meet or exceed all applicable provincial and local requirements, referenced standards and conform to codes and ordinances of authorities having jurisdiction.

.2 All installation shall be in accordance with manufacturer’s published recommendations.

.3 Extend duct insulation without interruption through walls, floors, and similar penetrations, except where otherwise indicated.

.4 Provide external insulation on all round ductwork connectors to ceiling diffusers and on top of diffusers. Secure insulation to the top of ceiling diffusers with ULC 181B-FX listed polypropylene duct tape Do not insulate top of ceiling diffuser if it is used in ceiling return air plenum or in an open space with no ceiling.

.5 Flexible and Rigid fiberglass insulation (Types D1 and D2) application for exterior of duct:

.1 Secure flexible insulation jacket joints with vapor barrier adhesive, tape. Tape shall be UL181B-FX listed polypropylene duct tape.

.2 Install without sag on underside of ductwork. Use 4-inch wide strips of adhesive on 8-inch centers and mechanical fasteners where necessary to prevent sagging. Seal vapor barrier penetrations by mechanical fasteners with vapor barrier adhesive. Stop and point insulation around access doors and damper operators to allow operation without disturbing wrapping.

.3 Insulate standing seams and stiffeners that protrude through the insulation with 1-1/2 inch thick, unfaced, flexible blanket insulation. Cover with reinforcing mesh and coat with vapor barrier finish coating.

.4 On circumferential joints, the 2-inch flange on the facing shall be secured with 9/16 inch outward clinch steel staples on 2-inch centers, and taped with minimum 3-inch wide strip of glass fabric and finish coating.

.5 Vapor seal all seams, joints, pin penetrations and other breaks with vapor barrier coating reinforced with reinforcing mesh.

.6 Insulation (Type D3) application for exterior of grease ducts:

.1 External duct wrap system requires two (2) 1.5-inch layers of lightweight, flexible wrap overlapped to provide an effective fire barrier. The barrier is installed in 24-inch or 48-inch wide sections. Insulation pins are welded in certain locations to maintain the fire barrier material up against the duct.

.2 Grease duct doors to be installed so the door can be removed and re installed and meet code requirements.

.3 Install duct wrap as tested per manufacturer's instructions to assure the duct wrap is mechanically attached per the manufacturer's spacing of bands or weld pins.

.4 Vertical and horizontal members of the support hanger system shall be wrapped with one layer of the insulation. Vertical and horizontal portions shall be wrapped independent of one another. The horizontal hanger shall be removed from the vertical support rods and wrapped and then immediately replaced so that an adjacent horizontal support can be removed, wrapped, and reinstalled. The end of the threaded vertical rod shall extend 6-inch past the horizontal member at the beginning of the installation.

.5 Penetrations: Where ducts penetrate fire rated walls, floors and roofs, the duct wrap shall be used in conjunction with a firestop system that is listed by a nationally recognized laboratory and rated for penetration of a rated wall or floor by the fire rated grease duct system used.

.7 Insulation (Type D4) application for outdoor ducts:

.1 Horizontal ductwork located outdoors shall be sloped at a minimum 2-degree angle to prevent the accumulation of water on top of the finished insulated duct. Support members that connect directly to the ductwork are to be insulated with this same material. Keep compression or sharp creases of outdoor insulation to a minimum by distributing the weight of the duct resting on horizontal duct support members.

.2 Follow the insulation manufacturer's installation instructions and procedures to assure the ductwork is properly insulated and that the insulation will meet the manufacturer's warranty requirements.

.3 Jacket Installation (Type D4) for outdoor ducts

a. Examine surfaces to receive waterproofing membrane. Notify Consultant if surfaces are not acceptable. Do not begin surface preparation or application until unacceptable conditions have been corrected.

b. Prepare surfaces in accordance with manufacturer's instructions. Ensure tops of ducts have sufficient slope to eliminate ponding water.

c. Ensure surfaces are clean and dry. Ensure bottoms of ducts have foil-faced rigid insulation boards installed.

d. Remove dirt, dust, oil, grease, hand oils, processing lubricants, moisture, frost, and other contaminants that could adversely affect adhesion of waterproofing membrane.

e. Apply membrane to clean, dry duct insulation. Do not apply over wet insulation

f. Apply waterproofing membrane in accordance with manufacturer's instructions. Apply membrane in accordance with manufacturer's air, material, and surface temperature requirements.

g. Apply membrane shingle fashion to shed water over, not against laps.Do not terminate membrane on bottom of duct.

h. Apply minimum 3-inch side laps and minimum 6-inch end laps for ductwork applications. Embed membrane to bottom of ducts over 24 inches wide in light continuous layer of adhesive applied to insulation facer.

i. Apply membrane to bottom of insulated ducts over 36 inches wide using mechanical attachment, in addition to adhesive, in accordance with manufacturer's instructions. Install pins on 12-inch centers with rows staggered.

j. Apply adhesive to areas where special adhesion requirements exist, including duct bottoms, flashings, transitions, joints, elbows, valves, tees, and other fittings.

.8 All ductwork, accessories, and all plenums including metal and masonry construction, etc., shall be insulated as specified herein and as required for a complete system. In each case, the insulation shall be equal to that specified and materials applied and finished as described in these Specifications.

.9 Flexible ductwork connections to equipment shall not be insulated.

.10 Where vapor barriers are required, the vapor barrier shall be on the outside. Extreme care shall be taken that the vapor barrier is unbroken. Joints, etc., shall all be sealed. Where insulation with a vapor barrier terminates, it shall be sealed off with the vapor barrier being continuous to the surface being insulated. Ends shall not be left raw.

.11 Extreme care shall be taken in insulating high and medium pressure ductwork including all ductwork between the fan discharge and all mixing boxes to ensure the duct is not pierced with sheet metal screws or other fasteners. All high and medium pressure ducts in these Specifications are classified as high velocity ductwork.

.12 Where canvas finish is specified use lagging adhesive/coating to prevent mildew in securing canvas. Do not use wheat paste.Use only anti fungal lagging adhesive that adheres to ASTM D 5590 with 0 growth rating. (Foster 30-36AF, Childers CP-137AF). In addition, cover all exterior canvas-covered insulation with a fire retardant weather barrier mastic.

.13 All supply ductwork in the Project shall be insulated unless noted specifically otherwise; all exhaust and fume hood exhaust ductwork shall not be insulated beyond 10 ft upstream of the penetration through exterior walls/roof unless used for energy recovery purposes or as otherwise noted on the drawings.

.14 Flexible round ducts shall be factory insulated.

3.3 INSPECTION

.1 Visually inspect the completed insulation installation per manufacturers recommended materials, procedures and repair or replace any improperly sealed joints.

.2 Where there is evidence of vapor barrier failure or “wet” insulation after installation, the damaged insulation shall be removed, duct surface shall be cleaned and dried and new insulation shall be installed.

3.4 DUCTWORK INSULATION APPLICATION AND THICKNESS SCHEDULE

Ductwork System	Application	Insulation Type	Insulation Thickness
Supply Air (Hot, Cold, Combination)	Outside of Mechanical Rooms	D1	2"
	Inside of Mechanical Rooms	D2	1½"

Ductwork System	Application	Insulation Type	Insulation Thickness
Return Air, Relief Air, and Exhaust Air	All	D1	1"
Outside Air	Inside the building	D1	2"
Kitchen Grease Hood Exhaust Air	All	D3	3"
Duct mounted coils	Inside of Mechanical Rooms	D2	2”
Terminal Unit Heating Coils	All	D1	2”
Supply Air Diffusers	Top of Diffuser	D1	2"
Supply Air Duct	Outdoor Environment	D4	2”
Return, Exhaust Air Duct	Outdoor Environment	D4	1½"

1 General

1.1 **GENERAL**

.1 This section of the specification shall be read in conjunction with and be governed by the requirements outlined in section 15010.

.2 Definitions

.1 Refrigerating system: Combination of interconnected refrigerant-containing parts constituting one closed refrigeration circuit in which a refrigerant is circulated for the purpose of extracting heat.

.2 Low side means the parts of a refrigerating system subjected to evaporator pressure.

.3 High side means the parts of a refrigerating system subjected to condenser pressure.

.4 Brazed joint: A gas-tight joint obtained by the joining of metal parts with alloys which melt at temperatures higher than 427 degrees C (800 degrees F) but less than the melting temperatures of the joined parts.

.3 Quality Assurance

.1 Comply with ASHRAE Standard 15, Safety Code for Mechanical Refrigeration. The application of this Code is intended to assure the safe design, construction, installation, operation, and inspection of every refrigerating system employing a fluid which normally is vaporized and liquefied in its refrigerating cycle.

.2 Comply with ASME Boiler and Pressure Vessel Code: Section IX: Welding and Brazing Qualifications.

.3 This section of the specification shall be read in conjunction with and shall be governed by the requirements outlined in Section 15010 of the specification

.4 Submittals

.1 Sizing of refrigerant lines shall be by the air conditioning equipment manufacturer, based on the total developed length of pipes, site-measured. Final pipe sizing shall be shown on the submittal documents.

.2 Shop Drawings: Sufficient information for components noted, including valves and refrigerant piping accessories, piping schematics, clearly presented, shall be included to determine compliance with drawings and specifications for components noted below:

.1 Tubing and fittings, including pipe sizes for each coil and condensing unit.
.2 Valves
.3 Strainers
.4 Moisture-liquid indicators
.5 Filter-driers

.6 Liquid-suction interchanges
.7 Oil separators (when specified)
.8 Gages
.9 Pipe and equipment supports
.10 Flexible elastomeric pipe insulation
.11 Refrigerant and oil
.12 Pipe/conduit roof penetration cover
.13 Soldering and brazing materials
.14 Indoor supports arrangement and manufacture
.15 Roof pipe supports and manufacture.

.3 Layout of refrigerant piping and accessories, including flow capacities, valves locations, and oil traps slopes of horizontal runs, floor/wall penetrations, and equipment connection details.

.4 Certification: Copies of certificates for welding procedure, performance qualification record and list of welders' names and symbols.

.5 Design Manual: Furnish two copies of design manual of refrigerant valves and accessories.

2 Products

2.1 **PIPING AND FITTINGS**

.1 Refrigerant Piping

.1 Copper refrigerant tube, ASTM B280, cleaned, dehydrated and sealed, marked ACR on hard temper straight lengths. Coils shall be tagged ASTM B280 by the manufacturer.

.2 Soldering:

.1 Solder joints: Wrought copper fittings, ANSI B16.22.

.2 Solder, refrigerant tubing: Cadmium free, AWS A5.8, 45 percent silver brazing alloy, Class Bag-5.

.3 Solder, water and drain: 95-5 tin-antimony, ASTM B32 (95TA).

.4 Flanges and flanged fittings: ANSI B16.24.

.3 Refrigeration Valves:

.1 Stop Valves: Brass or bronze alloy, packless, or packed type with gas tight cap, frost proof, backseating.

.2 Pressure Relief Valves: Forged brass with nonferrous, corrosion resistant internal working parts of high strength, cast iron bodies conforming to ASTM A126, Grade B. Set valves in accordance with ASHRAE Standard 15.

.3 Solenoid Valves: ARI 760, UL-listed, two-position, direct acting or pilot-operated,

moisture and vapor-proof type of corrosion resisting materials, designed for intended service, and solder-end connections. Fitted with suitable NEMA 250 enclosure of type required by location.

.4 Thermostatic Expansion Valves: Brass body with stainless-steel or non-corrosive non ferrous internal parts, diaphragm and spring-loaded (direct-operated) type with sensing bulb and distributor having side connection for hot-gas bypass and external equalizer. Size and operating characteristics as recommended by manufacturer of evaporator and factory set for superheat requirements. Solder-end connections. Testing and rating in accordance with ASHRAE Standard 17.

.5 Check Valves: Brass or bronze alloy with swing or lift type, with tight closing resilient seals for silent operation; designed for low pressure drop, and with solder-end connections. Direction of flow shall be legibly and permanently indicated on the valve body.

.6 Strainers: Designed to permit removing screen without removing strainer from piping system, and provided with screens 80 to 100 mesh in liquid lines up to 30 mm (1-1/8 inch), 60 mesh in liquid lines over 30 mm (1-1/8 inch), and 40 mesh in suction lines. Provide strainers in liquid line serving each thermostatic expansion valve, and in suction line serving each refrigerant compressor not equipped with integral strainer.

.7 Refrigerant Moisture/Liquid Indicators: Double-ported type having heavy sight glasses sealed into forged bronze body and incorporating means of indicating refrigerant charge and moisture indication. Provide screwed brass seal caps.

.8 Refrigerant Filter-Dryers: ULC listed, angle or in-line type, as shown on drawings. Conform to ASHRAE Standard 63. Heavy gage steel shell protected with corrosion-resistant paint; perforated baffle plates to prevent desiccant bypass. Size as recommended by manufacturer for service and capacity of system with connection not less than the line size in which installed. Filter driers with replaceable filters shall be furnished with one spare element of each type and size.

.9 Oil Separators: Provide for condensing units, where determined as necessary by the equipment manufacturer. All welded steel construction with capacity to eliminate a minimum of 95 percent of the oil from the hot gas flowing through it. Provide manufacturer's published ratings for minimum and maximum refrigeration tonnage corresponding to this oil separating efficiency. Conform to ASHRAE Standard 69. Separator shall be equipped with a float valve to prevent return of the hot gas to crankcase, and shall have isolating stop valves so it can be opened and services without pumping out any other part of the system. ASME construction or ULC listed.

2.2 PIPE SUPPORTS

.1 Refer to section 15010.

2.3 REFRIGERANTS AND OIL

.1 Provide required refrigerant and oil for proper system operation.

2.4 REFRIGERANT PIPE INSULATION

.1 All refrigerant piping shall be insulated with not less than 3/4" inch elastomeric closed cell insulation. The insulation shall conform to the OBC requirements for smoke and flame development.

.2 All refrigerant piping insulation mounted outdoors shall be covered with weatherproof aluminum jacketing.

.3 Acceptable insulation shall be: K-Flex Clad® AL. Elastomeric tube insulation (black) fully-adhered to an aluminum-finish jacketing that protects the insulation against damage from UV rays, mechanical abuse, moisture, and chemicals. It also serves as a second moisture vapor barrier

.4 All fittings for a complete water tight seal shall be provided by the manufacturer.

.5 Installation is as per manufacturer requirements/recommendations.

3 Execution

3.1 **INSTALLATION**

.1 Install refrigerant piping and refrigerant containing parts in accordance with the manufacturer's instructions, ASHRAE Standard 15 and ANSI B31.5. Refrigerant piping shall be brazed with 15 percent silver solder in accordance with AWS A5.8.

.2 Prior to installing the refrigerant piping, inspect the available ceiling space and select the most direct route, with minimal interference with the existing utilities and building elements.

.3 Drill adequate openings through the existing interior partitions, floors and roof to allow for the passage of the refrigerant piping. Where required allow for access doors. For roof penetrations, refer to details on the drawings.

.4 Make good all surfaces affected by the work.

.5 Horizontal runs shall be sloped toward compressor to insure oil return. Install piping as short as possible, with a minimum number of joints, elbow and fittings.

.6 The lines should be installed so that they will not obstruct services access to the indoor coil, air handling system or filter.

.7 Install piping with adequate clearance between pipe and adjacent walls and hangers to allow for service and inspection. Space piping, including insulation, to provide 25 mm (one inch) minimum clearance between adjacent piping or other surface. Use pipe sleeves through walls, floors, and ceilings, sized to permit installation of pipes with full thickness insulation.

.8 Swab fittings and valves with manufacturer's recommended cleaning fluid to remove oil and other compounds prior to installation.

.9 Install hangers and supports per section 15010, ANSI B31.5 and the refrigerant piping manufacturer's recommendations.

.10 Protect refrigerant system during construction against entrance of foreign matter, dirt and moisture; have open ends of piping and connections to compressors, condensers, evaporators and other equipment tightly capped until assembly.

.11 Under no circumstances shall the refrigerant compressor be used to evacuate the system. The evacuation shall be accomplished by the use of a vacuum pump at an ambient temperature not less than 35^{O}F to ensure removal of all moisture and non-condensable gases.

.12 Pass nitrogen gas through the pipe or tubing to prevent oxidation as each joint is brazed. Cap the system with a reusable plug after each brazing operation to retain the nitrogen and prevent entrance of air and moisture.

.13 Pipe relief valve discharge to outdoors for systems containing more than 45 kg (100 pounds) of refrigerant.

.14 Firestopping: Fill openings around uninsulated piping penetrating floors or fire walls, with firestop material.

.15 Apply flexible cellular insulation and fabricate fittings in accordance with the manufacturer's written instructions. Use proper size material. Do not stretch or strain insulation. To avoid undue compression of insulation, provide cork stoppers or wood inserts at supports as recommended by the insulation manufacturer.

.16 Where possible, slip insulation over the pipe or tubing prior to connection, and seal the butt joints with adhesive. Where the slip-on technique is not possible, slit the insulation and apply it to the pipe sealing the seam and joints with contact adhesive. Optional tape sealing, as recommended by the manufacturer, may be employed.

3.2 FIELD QUALITY CONTROL

.1 Prior to initial operation examine and inspect piping system for conformance to plans and specifications and ASME 31.5.

3.3 FIELD TESTS

.1 After completion of piping installation and prior to initial operation, conduct test on piping system according to ASME B31.5. Furnish materials and equipment required for tests. Perform tests in the presence of the consultant. If the test fails, correct defects and perform the test again until it is satisfactorily done and all joints are proved tight.

.2 The high and low side of each system shall be tested and proved tight at not less than the lower of the design pressure or the setting of the pressure-relief device protecting the high or low side of the system, respectively,

.3 Test Medium: A suitable dry gas such as nitrogen or shall be used for pressure testing. The means used to build up test pressure shall have either a pressure-limiting device or pressure-reducing device with a pressure-relief device and a gage on the outlet side. The pressure relief device shall be set above the test pressure but low enough to prevent permanent deformation of the system components.

3.4 SYSTEM TEST AND CHARGING

.1 System Test and Charging: As recommended by the equipment manufacturer or as follows:

.1 Connect a drum of refrigerant to charging connection and introduce enough refrigerant into system to raise the pressure to 70 kPa (10 psi) gage. Close valves and disconnect refrigerant drum. Test system for leaks with halide test torch or other approved method suitable for the test gas used. Repair all leaking joints and retest.

.2 Connect a drum of dry nitrogen to charging valve and bring test pressure to design pressure for low side and for high side Test entire system again for leaks.

.3 Evacuate the entire refrigerant system by the triplicate evacuation method with a vacuum pump equipped with an electronic gage reading in mPa (microns). Pull the system down to 665 mPa (500 microns) and hold for four hours then break the vacuum with dry nitrogen (or refrigerant). Repeat the evacuation two more times breaking the third vacuum with the refrigeration to be charged and charge with the proper volume of refrigerant.

- END -

1 General

1.1 **GENERAL**

.1 This section of the specification shall be read in conjunction with and be governed by the requirements outlined in section 15010.

1.2 **DESCRIPTION**

.1 Fuel gas systems, including piping, equipment and all necessary accessories as designated in this section.

1.3 **SUBMITTALS**

.1 Submit in accordance with Section 15010, shop drawings, product data, and samples.

.2 Manufacturer's Literature and Data:

.1 Piping.
.2 Strainers.
.3 All items listed in Part 2 - Products.
.4 Detailed shop drawing of clamping device and extensions when required in connection with the waterproofing membrane or the floor drain.

1.4 **APPLICABLE PUBLICATIONS**

.1 The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

.1 CAN1-B149.1-M80 for natural gas

.2 Ontario Natural Gas Code

.3 American National Standards Institute (ANSI):

.4 American Society of Mechanical Engineers (ASME): (Copyrighted Society)
.1 A13.1-96 Scheme for Identification of Piping Systems
.2 B16.3 98 Malleable Iron Threaded Fittings ANSI/ASME
.3 B16.9 01 Factory-Made Wrought Steel Buttwelding Fittings ANSI/ASME
.4 B16.11 01 Forged Steel Fittings, Socket-Welding and Threaded ANSI/ASME
.5 B16.15-85(R 1994) Cast Bronze Threaded Fittings ANSI/ASME
.6 B31.8-01 Gas Transmission and Distribution Piping Systems ANSI/ASME

.5 American Society for Testing and Materials (ASTM):
.1 A47-99 Ferritic Malleable Iron Castings Revision 1989
.2 A53-02 Pipe, Steel, Black And Hot-Dipped, Zinc-coated Welded and Seamless
.3 A183-83(R1998) Carbon Steel Track Bolts and Nuts

.4 A536-84(R1999) E1 Ductile Iron Castings
.5 A733-03 Welded and Seamless Carbon Steel and Austenitic Stainless Steel Pipe Nipples
.6 B687-99 Brass, Copper, and Chromium-Plated Pipe Nipples

.6 National Fire Protection Association (NFPA)

2 Products

2.1 **FUEL GAS SERVICE CONNECTIONS TO BUILDING**

.1 From inside face of exterior wall to a distance of approximately 1500 mm (5 feet) outside of building, use coated piping.

.2 Pipe: Black steel, ASTM A53, Schedule 40. Shop-applied pipe coating shall be one of the following types:

.1 Coal Tar Enamel Coating: Exterior of pipe and fittings shall be cleaned, primed with Type B primer and coated with hot-applied coal tar enamel with bonded layer of felt wrap in accordance with AWWA C203. Asbestos felt shall not be used; felt material shall be fibrous glass mat as specified in Appendix Section A2.1 of AWWA C203.

.2 Adhesive-thermoplastic Resin Coating: Fed. Spec. L-C-530, Type I.

.3 Thermosetting Epoxy Coating: Fed. Spec. L-C-530, Type II.

.4 Field-applied plastic tape material used on pipe joints and for repairing damaged areas of shop-applied coatings, Fed. Spec. L-T-1512, Type I, 10 mils nominal thickness for pipe joints, and Type II, 20 mils nominal thickness for coating repairs.

.3 Fittings:

.1 Butt weld fittings, wrought steel, ANSI B16.9.

.2 Socket weld and threaded fittings forged steel, ANSI B16.11.

.3 Grooved End: Ductile iron (ASTM A536, Grade 65-45-12), malleable iron (ASTM A47, Grade 32510), or steel (ASTM A53, Type F or Type E or S, Grade B).

.4 Joints: Welded, ANSI B31.8.

2.2 **FUEL GAS PIPING ABOVE-GROUND**

.1 Pipe: Black steel, ASTM A53, Schedule 40, seamless as follows:

.1 ½" to 1½" diam, screwed.

.2 2" to 10" welded, plain end.

.2 Nipples: Steel, ASTM A733, Schedule 40.

.3 Pipe fittings, screwed, flanged or welded as follows:

.1 Malleable iron screwed fittings (banded): Class 150 to ANSI B16.3-1977.
.2 Steel pipe flanges and flanged fittings: to ANSI B16.5-1977.
.3 Steel butt-welding fittings: to ANSI B16.9-1978.

.4 Unions, malleable iron, brass to iron, ground seat: to ANSI B16.3-1977.
.5 Bolts and nuts: to ANSI B18.2.1-1972 and ANSI B18.2.2-1972.
.6 Nipples, Schedule 40: to ASTM A53-82.

.4 Joints: Provide welded or threaded joints

2.3 JOINTING MATERIAL

.1 Screwed fittings: pulverized lead paste.

.2 Welded fittings: to CSA W47.1-1983.

.3 Flange gaskets: to ANSI B16.21-1978, ANSI B16.20-1973 or ANSI A21.11-1979.

2.4 WATERPROOFING

.1 Provide at points where pipes pass through membrane waterproofed floors or walls in contact with earth.

.2 Floors: Provide cast iron stack sleeve with flashing device and a underdeck clamp. After stack is passed through sleeve, provide a waterproofed caulked joint at top hub.

2.5 STRAINERS

.1 Provide on high pressure side of pressure reducing valves, on inlet side of indicating and control instruments and equipment subject to sediment damage and where shown on drawings. Strainer element shall be removable without disconnection of piping.

.2 Gas Lines: "Y" type with removable mesh lined brass strainer sleeve.

.3 Body: Smaller than 80 mm (3 inches), brass or bronze; 80 mm (3 inches) and larger, cast iron or semi steel.

2.6 DIELECTRIC FITTINGS

.1 Provide dielectric couplings or unions between ferrous and non ferrous pipe.

2.7 GAS EQUIPMENT CONNECTORS

.1 Flexible connectors with teflon core, interlocked galvanized steel protective casing, AGA certified design.

3 Execution

3.1 INSTALLATION

.1 General: Comply with the following:

.1 Install natural gas piping in accordance with CAN1-B149.1-M80

.2 Install branch piping for fuel gas and connect to all fixtures, valves, cocks, outlets, casework, cabinets and equipment.

.3 Pipe shall be round and straight. Cutting shall be done with proper tools. Pipe, except for plastic and glass, shall be reamed to full size after cutting.

.4 All pipe runs shall be laid out to avoid interference with other work.

.5 Slope piping down in direction of flow to low points.

.6 Use eccentric reducers at pipe size change installed to provide positive drainage.

.7 Provide clearance for access for maintenance of equipment, valves and fittings.

.8 Ream pipes, clean scale and dirt, inside and out.

.9 Cap open ends during construction to prevent entry of foreign material.

.10 Make connection to equipment with unions or flanges. Install piping to minimize pipe dismantling for equipment removal.

.11 Provide vents for all gas piping shafts in accordance to code.

.12 Install valves with stem in horizontal position whenever possible. All valves shall be easily accessible.

.13 Install union and shut-off valve on pressure piping at connections to equipment.

.14 Provide cathodic protection on jackets for all buried steel pipes, as per local gas supply company.

.15 Subcontractor installing buried gas piping shall be approved by the local gas supply company.

.16 Coordinate with the local gas supply company and the General Contractor the location of gas meter and isolation valves.

3.2 PURGING

.1 Purge after pressure test in accordance with applicable codes.

3.3 PIPE HANGERS, SUPPORTS AND ACCESSORIES

.1 All piping shall be supported AS per Section 15010 and Ontario Gas Code recommendations.

.2 Shop Painting and Plating: Hangers, supports, rods, inserts and accessories used for Pipe supports shall be shop coated with red lead or zinc Chromate primer paint. Electroplated copper hanger rods, hangers and accessories may be used with copper tubing.

.3 Floor, Wall and Ceiling Plates, Supports, Hangers:

.1 Solid or split unplated cast iron.

.2 All plates shall be provided with set screws.

.3 Pipe Hangers: Height adjustable clevis type.

.4 Adjustable Floor Rests and Base Flanges:Steel.

.5 Concrete Inserts: "Universal" or continuous slotted type.

.6 Hanger Rods: Mild, low carbon steel, fully threaded or Threaded at each end with two removable nuts at each end for positioning rod and hanger and locking each in place.

.7 Riser Clamps: Malleable iron or steel.

.8 Rollers: Cast iron.

.9 Self-drilling type expansion shields shall be "Phillips" type, with case hardened steel expander plugs.

.4 Hangers and supports utilized with insulated pipe and tubing shall have 180 degree (min.) metal protection shield Centered on and welded to the hanger and support. The shield shall be 4 inches in length and be 16 gauge steel. The shield shall be sized for the insulation.

.5 Miscellaneous Materials: As specified, required, directed or as noted on the drawings for proper installation of hangers, supports and accessories. If the vertical distance exceeds 6 m (20 feet) for cast iron pipe additional support shall be provided in the center of that span. Provide all necessary auxiliary steel to provide that support.

.6 Install cast escutcheon with set screw at each wall, floor and ceiling penetration in exposed finished locations and within cabinets and millwork.

3.4 PENETRATIONS

.1 Fire Stopping: Where pipes pass through fire partitions, fire walls, smoke partitions, or floors, install a fire stop that provides an effective barrier against the spread of fire, smoke and gases. Completely fill and seal clearances between raceways and openings with the fire stopping materials.

.2 Waterproofing: At floor penetrations, completely seal clearances around the pipe and make watertight with sealant

.3 Piping shall conform to the following:

.1 Entire fuel gas piping installation shall be in accordance with requirements of NFPA 54.

.2 Install fuel gas piping with plugged drip pockets at low points.

3.5 TESTS

.1 General: Test system either in its entirety or in sections.

.2 Fuel Gas System: NFPA 54.

3.6 PAINTING

.1 Paint the entire gas line yellow; where exposed to the outdoors, use outdoor-grade paint.

- END -

1 General

1.1 GENERAL

.1 This section of the specification shall be read in conjunction with and be governed by the requirements of Section 15010.

1.2 DESCRIPTION

.1 Ductwork and accessories for HVAC including the following:

.1 Supply air, return air, outside air, exhaust, and relief systems.

1.3 DEFINITIONS

.1 SMACNA Standards as used in this specification means the HVAC Duct Construction Standards, Metal and Flexible.

.2 Seal or Sealing: Use of liquid or mastic sealant, with or without compatible tape overlay, or gasketing of flanged joints, to keep air leakage at duct joints, seams and connections to an acceptable minimum.

.3 Duct Pressure Classification: SMACNA HVAC Duct Construction Standards, Metal and Flexible.

.4 Exposed Duct: Exposed to view in a finished room, and/or exposed to weather.

1.4 QUALITY ASSURANCE

.1 Fire Safety Code: Comply with NFPA 90A.

.2 Duct System Construction and Installation: Referenced SMACNA Standards are the minimum acceptable quality.

.3 Duct Sealing, Air Leakage Criteria, and Air Leakage Tests: Ducts shall be sealed as per duct sealing requirements of SMACNA HVAC Air Duct Leakage Test Manual for duct pressure classes shown on the drawings.

.4 Duct accessories exposed to the air stream, such as dampers of all types (except smoke dampers) and access openings, shall be of the same material as the duct or provide at least the same level of corrosion resistance.

1.5 SUBMITTALS

.1 Submit in accordance with Section 15010, Manufacturer's Literature and Data:

.1 Rectangular ducts:

.1 Schedules of duct systems, materials and selected SMACNA construction alternatives for joints, sealing, gage and reinforcement.
.2 Sealants and gaskets.

.3 Access doors.

.2 Round and flat oval duct construction details:
.1 Manufacturer's details for duct fittings.
.2 Sealants and gaskets.

.3 Access sections.
.4 Volume dampers, back draft dampers.
.5 Upper hanger attachments.
.6 Fire dampers, fire doors, and smoke dampers with installation instructions.
.7 Sound attenuators, including pressure drop and acoustic performance.
.8 Flexible ducts and clamps, with manufacturer's installation instructions.
.9 Flexible connections.
.10 Instrument test fittings.
.11 Details and design analysis of alternate or optional duct systems.

1.6 APPLICABLE PUBLICATIONS

.1 The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.

.2 Air Moving and Conditioning Association (AMCA):

.1 500D 98 Laboratory Method of Testing Dampers for Rating
.2 500L-99 Laboratory Method of Testing Louvers for Rating

.3 American Society for Testing and Materials (ASTM):

.1 A653-01 Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy coated (Galvannealed) by the Hot-Dip process
.2 A1011-02 Standard Specification for Steel Sheet and Strip Hot rolled Carbon structural, High-Strength Low- Alloy and High Strength Low-Alloy with Improved Formability
.3 B209 01 Standard Specification for Aluminum and Aluminum Alloy Sheet and Plate
.4 C1071-00 Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material)
.5 E84-01 Standard Test Method for Surface Burning Characteristics of Building Materials

.4 National Fire Protection Association (NFPA):

.1 90A-99 Standard for the Installation of Air Conditioning and Ventilating Systems
.2 96-01 Ventilation Control and Fire Protection of Commercial Cooking Operations

.5 Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

.1 2nd Edition – 1995 HVAC Duct Construction Standards, Metal and Flexible
.2 1st Edition, 1985 HVAC Air Duct Leakage Test Manual
.3 6th Edition – 1992 Fibrous Glass Duct Construction Standards

2 Products

2.1 DUCT MATERIALS

.1 General: Except for systems specified otherwise, construct ducts, casings, and accessories of galvanized sheet steel, ASTM A527, coating G90; or, aluminum sheet, ASTM B209, alloy 1100, 3003 or 5052.

.2 Specified Corrosion Resistant Systems: Stainless steel sheet, ASTM A167, Class 302 or 304, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.

2.2 GALVANIZED STEEL - RECTANGULAR DUCTWORK

.1 G-90 coated galvanized of lockforming grade conforming to ASTMA653 and A924 Standards. Minimals yield strength for steel sheet and reinforcements shall be 30,000 PSI (207 kPa).

.2 Thickness: to ASHRAE and SMACNA.

.3 Fabrication: to ASHRAE and SMACNA.

.4 Joints: to ASHRAE and SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint shall be considered to be a class B seal.

.1 Standard of Acceptance: Namasco Ductmate; Exanno Nexus.

.5 Fittings

.1 Fabrication: to SMACNA.

.2 Radiused elbows: standard radius.

.3 Square elbows: over 16" with double thickness vanes. Not to be used unless specifically shown on drawings.

.4 Main supply duct branches with splitter damper. If splitter damper is not used, provide branch and main duct balancing damper.

.5 Sub branch duct with 45° entry and balancing damper on branch.

.6 Transitions:

.1 Diverging: 20° maximum included angle.
.2 Converging: 30° maximum included angle.

.7 Offsets: radiussed elbows as indicated.

.8 Obstruction deflectors: maintain full cross- sectional area. Maximum included angles as for transitions.

2.3 GALVANIZED STEEL - ROUND DUCTWORK

.1 All round ductwork up to 1500 mm (60") in diameter shall be of spiro lockseam construction with an intermediate standard rib to provide the rigidity equivalent to ASHRAE standard gauge spiral duct.

.2 G-90 coated galvanized of lockforming grade conforming to ASTM A653 and A924 Standards. Minimum yield strength for steel sheet and reinforcements shall be 30,000 PSI (207 KPA) with a thickness not less than for 24 gauge for duct diameters 250 mm to 425 mm (10" to 17"), 22 gauge for 450 mm to 600 mm (18" to 24"), 20 gauge for 650 mm to 800 mm (26" to 30") and 18 gauge for 850 mm to 1500 mm (32" to 60") diameters.

.3 For duct diameters less than 10", use 26 gauge spiro duct without ribs.

.4 Fittings:

.1 Elbows 4" to 8" diam., shall be die stamped. Diestamped elbows are to be two piece construction with fully welded longitudinal seam.

.2 Elbows 10" to 30" shall be standing seam construction.

.3 Fittings shall be one gauge thicker than standard ductwork.

.5 All couplings shall be slipped joint construction with minimum 50 mm insertion length. Duct sealer to be applied on male end connectors before insertion and afterwards to cover the entire joint and sheet metal screws. Sheet metal screws shall be installed at a maximum 300 mm spacing, with a minimum of 3 screws per joint. In large diameters flanging gasketted joints are acceptable in lieu of slip joints.

2.4 SEALING CLASSIFICATION

.1 Sealing classification as follows:

Seal Class	Sealing Requirements	Applicable Static Pressure Construction Class	Allowable Leakage Rate
A	All traverse joints, longitudinal seams and duct wall penetrations	4" w.g. (1000 Pa) -4" w.g. (-1000 Pa)	1% of total system design at system operating pressure 4"(1000 Pa)
B	All transverse joints and longitudinal seams	Up to 3" w.g. (750 Pa) -3" w.g. (-750 Pa) and less	1% of total system design at 3" w.g. (750 Pa)
C	All transverse joints only	Up to 2" w.g. (500 Pa) -2" w.g. (500 Pa) and less	1.5% of total system design at 2" w.g. (500 Pa)
D	Not sealed	Up to 1" w.g. (250 Pa) -1" w.g. (-250 Pa) and less	5% of total system design at 1" w.g. (250 Pa)

2.5 PRESSURE CLASSIFICATIONS

.1 Ductwork material shall be constructed in accordance with SMACNA ratings for the following pressure classifications. Seal classifications shall be in accordance with the following table:

Ductwork	Operating Pressure	Seal Classification	Remarks
All supply ductwork	Up to 2". w.g. (500 Pa)	B	
All return ductwork	Up to 1 " w.g. (250 Pa)	C	
All exhaust ductwork	Up to -1" w.g. (-250 Pa)	C	
All Other Ductwork Not Listed Above	Up to 0.5" w.g. (125 Pa)	D	

2.6 SEALANT AND TAPE

.1 Joint Sealing: Refer to SMACNA HVAC Duct Construction Standards, paragraph S1.9.

.2 Sealant: Elastomeric compound, gun or brush grade, maximum 25 flame spread and 50 smoke developed (dry state) compounded specifically for sealing ductwork as recommended by the manufacturer. Generally provide liquid sealant, with or without compatible tape, for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger. Oil base caulking and glazing compounds are not acceptable because they do not retain elasticity and bond.

.3 Tape: Use only tape specifically designated by the sealant manufacturer and apply only over wet sealant. Pressure sensitive tape shall not be used on bare metal or on dry sealant.

.4 Gaskets in Flanged Joints: Soft neoprene.

.5 Approved factory made joints such as DUCTMATE SYSTEM may be used.

2.7 DUCT CONSTRUCTION AND INSTALLATION

.1 Follow SMACNA HVAC Duct Construction Standards.

.2 Showers exhaust ductwork, dishwasher exhaust ductwork, all outdoor-located ductwork shall be made liquid tight with continuous external weld for all seams and joints. Provide neoprene gaskets at flanged connections. Where ducts are not self draining back to the equipment, provide low point drain pocket with copper drain pipe to sanitary sewer. Provide access door in side of duct at drain pockets.

.3 Round and Flat Oval Ducts

.1 Furnish duct and fittings made by the same manufacturer to insure good fit of slip joints. When submitted and approved in advance, round and flat oval duct, with size converted on the basis of equal pressure drop, may be furnished in lieu of rectangular duct design shown on the drawings.

.2 Elbows: Diameters 80 through 200 mm (3 through 8 inches) shall be two sections die stamped, all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

.3 Provide bell mouth, conical tees or taps, laterals, reducers, and other low loss fittings as shown in SMACNA HVAC Duct Construction Standards.

.4 Ribbed Duct Option: Lighter gage round/oval duct and fittings may be furnished provided certified tests indicating that the rigidity and performance is equivalent to SMACNA standard gage ducts are submitted.

.5 Ducts: Manufacturer's published standard gage, G90 coating, spiral lock seam construction with an intermediate standing rib.

.6 Fittings: May be manufacturer's standard as shown in published catalogs, fabricated by spot welding and bonding with neoprene base cement or machine formed seam in lieu of continuous welded seams.

.7 Provide flat side reinforcement of oval ducts as recommended by the manufacturer and SMACNA HVAC Duct Construction Standard S3.13. Because of high pressure loss, do not use internal tie rod reinforcement unless approved by the Consultant.

.4 Casings and Plenums

.1 Construct in accordance with SMACNA HVAC Duct Construction Standards Section 6, including curbs, access doors, pipe penetrations, eliminators and drain pans. Access doors shall be hollow metal, insulated, with latches and door pulls, 500 mm (20 inches) wide by 1200 - 1350 mm (48 54 inches) high. Provide view port in the doors where shown. Provide drain for outside air louver plenum. Outside air plenum shall have exterior insulation. Drain piping shall be routed to the nearest floor drain.

.5 Volume Dampers

.1 opposed blade, multi louver type as detailed in SMACNA Standards. Refer to SMACNA Detail Figure 2-12 for Single Blade and Figure 2.13 for Multi-blade Volume Dampers.

.6 Outdoor ductwork support: refer to details on drawings.

2.8 HANGERS AND SUPPORTS

.1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.

.2 Hanger configuration: to ASHRAE and SMACNA. Maximum size duct supported by strap hanger: 500mm.

.3 Hangers: galvanized steel angle with black galvanized steel rods to ASHRAE and SMACNA following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1500	40 x 40 x 3	10
1501 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

.4 Upper hanger attachments:

.1 For concrete: manufactured concrete inserts.

.1 Standard of Acceptance: Myatt fig 485.

.2 For concrete after concrete pour:

.1 Expanded concrete anchors shall be made of steel.

.2 Powder actuated fasteners shall only be utilized for slabs that are thicker than

100 mm (4") and shall not be utilized in lightweight aggregate concretes.

.3 Holes for expanding fasteners shall be drilled either by a carbide bit or by the teeth on the fastener itself. Expansion shield shall be “set" by driving it into the hole and expanding it with a conical plug.

.3 For steel joist: manufactured joist clamp or steel plate washer.

.1 Standard of Acceptance: Grinnell fig 61 or 86 for joist clamps.

.4 For steel beams: manufactured beam clamps:

.1 Standard of Acceptance: Grinnell fig. 60

.5 For round ductwork the duct shall be supported as follows:

.1 For duct dimensions 900 mm (36") single hangers are acceptable.

.2 For duct dimensions over 900 mm (36") hanger rods shall be provided on both sides of the duct.

.3 Minimum hanger sizes shall be in accordance with table 4-2 of SMACNA.

.6 Loading on trapeze bars shall be in accordance with Table 4-3 of SMACNA.

2.9 DUCT ACCESS DOORS, PANELS AND SECTIONS

.1 Provide access doors, sized and located for maintenance work, upstream, in the following locations:

.1 Each duct mounted coil and humidifier. For duct mounted coils, provide access doors downstream of the coil as well

.2 Each fire damper (for link service), smoke damper and automatic control damper.

.3 Each duct mounted smoke detector.

.4 For cleaning operating room supply air duct and kitchen hood exhaust duct, locate access doors at 6 m (20 feet) intervals and at each change in duct direction.

.2 Openings shall be as large as feasible in small ducts, 300 mm by 300 mm (12 inch by 12 inch) minimum where possible. Access sections in insulated ducts shall be double wall, insulated. Transparent shatterproof covers are preferred for uninsulated ducts.

.3 For rectangular ducts: Refer to SMACNA HVAC Duct Construction Standards (Figure 2 12).

.4 For round and flat oval duct: Refer to SMACNA HVAC duct Construction Standards (Figure 2-11).

2.10 FIRE DOORS

.1 Galvanized steel, interlocking blade type, UL listing and label, 71 degrees C (160 degrees F) fusible link, 3 hour rating and approved for openings in Class A fire walls with rating up to 4 hours, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

2.11 FLEXIBLE DUCTWORK

.1 Factory fabricated, complying with NFPA 90A for connectors not passing through floors of buildings. Flexible ducts shall not penetrate any fire or smoke barrier which is required to have a fire resistance rating of one hour or more. Flexible duct length shall not exceed 1.5 m (5 feet).

.2 Flexible ducts shall be listed by Underwriters Laboratories, Inc., complying with UL 181. Ducts larger than 200 mm (8 inches) in diameter shall be Class 1. Ducts 200 mm (8 inches) in diameter and smaller may be Class 1 or Class 2.

.3 Insulated Flexible Air Duct – all conditioned supply air ductwork : Factory made including mineral fiber insulation with maximum C factor of 0.25 at 24 degrees C (75 degrees F) mean temperature, encased with a low permeability moisture barrier outer jacket, having a puncture resistance of not less than 50 Beach Units. Acoustic insertion loss shall not be less than 3 dB per 300 mm (foot) of straight duct, at 500 Hz, based on 150 mm (6 inch) duct, of 750 m/min (2500 fpm).

.4 Application Criteria:

.1 Temperature range: -18 to 93 degrees C (0 to 200 degrees F) internal.
.2 Maximum working velocity: 1200 m/min (4000 feet per minute).
.3 Minimum working pressure, inches of water gage: 2500 Pa (10 inches) positive, 500 Pa (2 inches) negative.

.5 Duct Clamps: stainless steel strap with cadmium plated worm gear tightening device. Apply clamps with sealant and as approved for UL 181, Class 1 installation. Secure with min. 2 additional screws.

2.12 FLEXIBLE CONNECTIONS

.1 Refer to section 15241

2.13 INSTRUMENT TEST FITTINGS

.1 Manufactured type with a minimum 50 mm (two inch) length for insulated duct, and a minimum 25 mm (one inch) length for duct not insulated. Test hole shall have a flat gasket for rectangular ducts and a concave gasket for round ducts at the base, and a screw cap to prevent air leakage.

.2 Provide instrument test holes at each duct or casing mounted temperature sensor or transmitter, and at entering and leaving side of each heating coil, cooling coil, and heat recovery unit.

3 Execution

3.1 INSTALLATION

.1 Fabricate and install ductwork and accessories in accordance with referenced SMACNA Standards:

.2 Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, boxes, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets at no additional cost to the Owner. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions which shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.

.3 Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards, Section II. Provide streamliner, when an obstruction cannot be avoided and must be taken in by a duct. Repair galvanized areas with galvanizing repair compound.

.4 Supply and install volume control dampers on all branch take-offs (applicable to supply, return and exhaust ductwork) wether shown on the drawing or not.

.5 Provide bolted construction and tie rod reinforcement in accordance with SMACNA Standards.

.6 Construct casings, eliminators, and pipe penetrations in accordance with SMACNA Standards, Chapter 6. Design casing access doors to swing against air pressure so that pressure helps to maintain a tight seal.

.7 Install duct hangers and supports in accordance with SMACNA Standards, Chapter 4.

.8 Install fire dampers in accordance with the manufacturer's instructions to conform to the installation used for the rating test.

.9 Seal openings around duct penetrations of floors and fire rated partitions with fire stop material as required by NFPA 90A.

.10 Flexible duct installation: Refer to SMACNA Standards, Chapter 3. Ducts shall be continuous, single pieces not over 1.5 m (5 feet) long (NFPA 90A), as straight and short as feasible, adequately supported. Centerline radius of bends shall be not less than two duct diameters. Make connections with clamps as recommended by SMACNA. Clamp per SMACNA with one clamp on the core duct and one on the insulation jacket. Flexible ducts shall not penetrate floors, or any chase or partition designated as a fire or smoke barrier, including corridor partitions fire rated one hour or two hour. Support ducts SMACNA Standards.

.11 Where diffusers, registers and grilles cannot be installed to avoid seeing inside the duct, paint the inside of the duct with flat black paint to reduce visibility.

.12 Control Damper Installation:

.1 Provide necessary blank off plates required to install dampers that are smaller than duct size. Provide necessary transitions required to install dampers larger than duct size.

.2 Assemble multiple sections dampers with required interconnecting linkage and extend required number of shafts through duct for external mounting of damper motors.

.3 Provide necessary sheet metal baffle plates to eliminate stratification and provide air volumes specified. Locate baffles by experimentation, and affix and seal permanently in place, only after stratification problem has been eliminated.

.4 Install all damper control/adjustment devices on stand-offs to allow complete coverage of insulation.

.13 Air Flow Measuring Devices (AFMD): Install units with minimum straight run distances, upstream and downstream as recommended by the manufacturer.

.14 Protection and Cleaning: Adequately protect equipment and materials against physical damage. Place equipment in first class operating condition, or return to source of supply for repair or replacement, as determined by the Consultant. Protect equipment and ducts during construction against entry of foreign matter to the inside and clean both inside and outside before operation and painting. When new ducts are connected to existing ductwork, clean both new and existing ductwork by mopping and vacuum cleaning inside and outside before operation.

3.2 DUCT LEAKAGE TESTS AND REPAIR

.1 Ductwork leak test shall be performed for the entire air distribution supply and return system including fans, coils and filter section designated as static pressure class 750 Pa (3 inch W.G.) and above.

.2 All supply ductwork less than 500 Pa (2 inch W.G) shall also be tested to the air distribution equipment or terminal device (where applicable)

.3 Test procedure, apparatus and report shall conform to SMACNA Leakage Test manual. The maximum leakage rate allowed is 4 percent of the design air flow rate.

.4 All ductwork shall be leak tested first before enclosed in a shaft or covered in other inaccessible areas.

.5 All tests shall be performed in the presence of the TAB agency. The Test and Balance agency shall measure and record duct leakage and report to the Consultant and identify leakage source with excessive leakage.

.6 If any portion of the duct system tested fails to meet the permissible leakage level, the Contractor shall rectify sealing of ductwork to bring it into compliance and shall retest it until acceptable leakage is demonstrated to the Consultant.

.7 All tests and necessary repairs shall be completed prior to insulation or concealment of ductwork.

.8 Make sure all openings used for testing flow and temperatures by TAB Contractor are sealed properly.

- END -

1 General

1.1 **GENERAL**

.1 This section of the specification shall be read in conjunction with and be governed by the requirements of Section 15010.

1.2 **PRODUCT DATA**

.1 Submit product data in accordance with Section 15010.

2 Products

2.1 **SPLITTER DAMPERS**

.1 Of same material as duct but one sheet metal thickness heavier.

.2 Single thickness construction.

.3 Size and configuration to recommendations of SMACNA.

.4 Control rod with locking device.

.5 Bend end of rod to prevent end from entering duct.

.6 Pivot: piano hinge.

2.2 **SINGLE BLADE DAMPERS**

.1 Of same material as duct. V-groove stiffened.

.2 Size and configuration to recommendations of SMACNA, except maximum height 10"

.3 Locking quadrant.

.4 Inside and outside end bearings.

2.3 **MULTI-BLADED DAMPERS**

.1 Factory manufactured of material compatible with duct.

.2 Opposed blade: configuration to recommendations of SMACNA.

.3 Maximum blade height: 4"

.4 Bearings: pin in bronze bushings.

.5 Linkage: shaft extension with locking quadrant.

.6 Channel frame complete with angle stop.

2.4 **DIVERTING DAMPERS**

.1 Adjustable, curved vanes, mounted in supporting frame.

.2 All aluminum construction.

3 Execution

3.1 **INSTALLATION**

.1 Install where indicated on the drawings and identified herein. For ducts concealed behind plaster or drywall ceilings, provide dampers where specifically shown on the drawings.

.2 Provide splitter damper at every main branch take-off from main duct.

.3 Provide balancing damper on all sub-branch ducts.

.4 Install in accordance with recommendations of SMACNA.

.5 Provide balancing dampers on all return air ducts connected to air handling units.

- END -

Part 1 – General

1.01 References

A. AFBMA 9 - Load Ratings and Fatigue Life for Ball Bearings.
B. AMCA 99—Standards Handbook
C. AMCA 500—Test Methods for Louver, Dampers, and Shutters.
D. AHRI 340/360 - Unitary Large Equipment
E. NEMA MG1—Motors and Generators
F. National Electrical Code.
G. NFPA 70—National Fire Protection Agency.
H. SMACNA—HVAC Duct Construction Standards—Metal and Flexible.
I. UL 900—Test Performance of Air Filter Units

1.02 General Description

A. This section includes the design, controls and installation requirements for packaged rooftop units / outdoor air handling units.

B. RTU-1 (A&B) (Gym RTU): supply fan, exhaust fan, DX cooling, gas heating, OA control by CO2. Will be installed on horizontal discharge roof curb

1.03 Quality Assurance

A. Packaged air-cooled condenser units shall be certified in accordance with ANSI/AHRI Standard 340/360 performance rating of commercial and industrial unitary air-conditioning and heat pump equipment.

B. Unit shall be certified in accordance with UL Standard 1995/CSA C22.2 No. 236, Safety Standard for Heating and Cooling Equipment.

C. Unit and refrigeration system shall comply with ASHRAE 15, Safety Standard for Mechanical Refrigeration.

D. Unit shall be certified in accordance with ANSI Z21.47b/CSA 2.3b and ANSI Z83.8/CSA 2.6, Safety Standard Gas-Fired Furnaces.

E. Unit Energy Efficiency Ratio (EER) shall be equal to or greater that prescribed by ASHRAE 90.1, Energy Efficient Design of New Buildings except Low-Rise Residential Buildings.

F. Unit shall be certified by ETL and ETL Canada listed. Unit nameplate shall include the ETL/ETL Canada label. The nameplate, safety labels and warnings will be in English and French.

1.04 Submittals

A. Product Data: Literature shall be provided that indicates dimensions, operating and shipping weights, capacities, ratings, fan performance, filter information, factory supplied accessories, electrical characteristics and connection requirements. Installation, Operation, and Maintenance manual with startup requirements shall be provided.

B. Shop Drawings: Unit drawings shall be provided that indicate assembly, unit dimensions, construction details, clearances and connection details. Computer generated fan curves for each fan shall be submitted with specific design operation point noted. Wiring diagram shall be provided with details for both power and control systems and differentiate between factory installed and field installed wiring.

1.05 Delivery, Storage, and Handling

A. Unit shall be shipped with doors screwed shut and outside air hood closed to prevent damage during transport and thereafter while in storage awaiting installation.

B. Follow Installation, Operation, and Maintenance manual instructions for rigging, moving, and unloading the unit at its final location.

C. Unit shall be stored in a clean, dry place protected from construction traffic in accordance with the Installation, Operation, and Maintenance manual.

1.06 Warranty

A. Manufacturer shall provide a limited “parts only” warranty for a period of 12 months from the date of equipment startup or 18 months from the date of original equipment shipment from the factory, whichever is less. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided manufacturer’s written instructions for Installation, Operation, and maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts and filters.

Part 2 - Products

2.01 Manufacturer

A. Products shall be provided by the following manufacturers:

1. AAON (base design)

2. Alternatives: Daikin, Engineered Air

3. *The basis of design for footprint, electric power, performance and weight is AAON. Should the contractor select an alternative manufacturer, the contractor remains responsible for all work and cost for structural, electrical, and mechanical adjustments necessary to install the new equipment.*

2.02 Rooftop Units

A. General Description

1. Packaged rooftop unit shall include compressors, evaporator coils, filters, supply fans, dampers, air-cooled condenser coils, condenser fans, gas heaters, exhaust fans, energy recovery wheels, and unit controls.

2. Unit shall be factory assembled and tested including leak testing of the DX coils, pressure testing of the refrigeration circuit, and run testing of the completed unit. Run test report shall be supplied with the unit in the service compartment’s

literature pocket.

3. Unit shall have decals and tags to indicate lifting and rigging, service areas and caution areas for safety and to assist service personnel.

4. Unit components shall be labeled, including refrigeration system components, and electrical and controls components.

5. Estimated sound power levels (dB) shall be shown on the unit ratings sheet.

6. Installation, Operation, and Maintenance manual shall be supplied within the unit.

7. Laminated color-coded wiring diagram shall match factory installed wiring and shall be affixed to the interior of the control compartment's hinged access door.

8. Unit nameplate shall be provided in two locations on the unit, affixed to the exterior of the unit and affixed to the interior of the control compartment's hinged access door.

B. Construction

1. All cabinet walls, access doors, and roof shall be fabricated of double wall, impact resistant, rigid polyurethane foam panels.

2. Unit insulation shall have a minimum thermal resistance R-value of 13. Foam insulation shall have a minimum density of 2 pounds/cubic foot and shall be tested in accordance with ASTM D1929-11 for a minimum flash ignition temperature of 610°F.

3. Unit construction shall be double wall with G90 galvanized steel on both sides and a thermal break. Double wall construction with a thermal break prevents moisture accumulation on the insulation, provides a cleanable interior, reduces heat transfer through the panel, and prevents exterior condensation on the panel.

4. Unit shall be designed to reduce air leakage and infiltration through the cabinet. Cabinet leakage shall not exceed 1% of total airflow when tested at 3 times the minimum external static pressure provided in AHRI Standard 340/360. Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, at a maximum 8 inches of positive or negative static pressure, to reduce air leakage. Deflection shall be measured at the midpoint of the panel height and width. Continuous sealing shall be included between panels and between access doors and openings to reduce air leakage. Piping and electrical conduit through cabinet panels shall include sealing to reduce air leakage.

5. Roof of the air tunnel shall be sloped to provide complete drainage. Cabinet shall have rain break overhangs above access doors.

6. Access to filters, dampers, cooling coils, heaters, energy recovery wheels, compressors, and electrical and controls components shall be through hinged access doors with quarter turn, zinc cast, lockable handles. Full length stainless

steel piano hinges shall be included on the doors.

7. Exterior paint finish shall be capable of withstanding at least 2,500 hours, with no visible corrosive effects, when tested in a salt spray and fog atmosphere in accordance with ASTM B 117-95 test procedure.

8. Units with cooling coils shall include double sloped 304 stainless steel drain pans.

9. Unit shall be provided with horizontal discharge and horizontal return air openings. All openings through the base pan of the unit shall have upturned flanges of at least 1/2 inch in height around the opening.

10. Unit shall include lifting lugs on the top of the unit.

C. Electrical

1. Unit shall be provided with factory installed and factory wired, non-fused disconnect switch.

2. Unit shall be provided with a factory installed and field wired 115V, 20 amp GFI outlet in the unit control panel.

3. Unit shall be provided with phase and brown out protection which shuts down all motors in the unit if the electrical phases are more than 10% out of balance on voltage, the voltage is more than 10% under design voltage or on phase reversal.

D. Supply Fans

1. Unit shall include direct drive, unhoused, backward curved, plenum supply fans.

2. Blowers and motors shall be dynamically balance and mounted on rubber isolators.

3. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

4. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

E. Exhaust Fans

1. Exhaust dampers shall be sized for 100% relief.

2. Fans and motors shall be dynamically balanced.

3. Unit shall include barometric relief dampers.

4. Motors shall be premium efficiency ODP with ball bearings rated for 200,000 hours service with external lubrication points.

5. Access to exhaust fans shall be through double wall, hinged access doors with

quarter turn lockable handles.

6. Unit shall include belt driven, unhoused, backward curved, plenum exhaust fans.

7. Variable frequency drives shall be factory wired and mounted in the unit. Fan motors shall be premium efficiency.

F. Cooling Coils

1. Evaporator Coils

a. Coils shall be designed for use with R-410A refrigerant and constructed of copper tubes with aluminum fins mechanically bonded to the tubes and galvanized steel end casings. Fin design shall be sine wave rippled.

b. Coils shall have interlaced circuitry and shall be 6 row high capacity.

c. Coils shall be hydrogen or helium leak tested.

d. Coils shall be furnished with factory installed expansion valves.

G. Refrigeration System

1. Unit shall be factory charged with R-410A refrigerant.

2. Compressors shall be scroll type with thermal overload protection and carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory.

3. Compressors shall be mounted in an isolated service compartment which can be accessed without affecting unit operation. Lockable hinged compressor access doors shall be fabricated of double wall, rigid polyurethane foam injected panels to prevent the transmission of noise outside the cabinet.

4. Compressors shall be isolated from the base pan with the compressor manufacturer's recommended rubber vibration isolators, to reduce any transmission of noise from the compressors into the building area.

5. Each refrigeration circuit shall be equipped with expansion valve type refrigerant flow control.

6. Each refrigeration circuit shall be equipped with automatic reset low pressure and manual reset high pressure refrigerant safety controls, Schrader type service fittings on both the high pressure and low pressure sides and a factory installed liquid line filter driers.

7. Unit shall include a variable capacity scroll compressor on the lead refrigeration circuit which shall be capable of modulation from 10-100% of its capacity.

8. The factory installed controls shall include a 3 minute off delay timer to prevent compressor short cycling. The controls shall also include an adjustable, 20

second delay timer for each additional capacity stage to prevent multiple capacity stages from starting simultaneously and adjustable compressor lock out.

H. Condensers

1. Air-Cooled Condenser

a. Condenser fans shall be a vertical discharge, axial flow, direct drive fans.

b. Coils shall be designed for use with R-410A refrigerant. Coils shall be multi-pass and fabricated from aluminum microchannel tubes.

c. Coils shall be designed for a minimum of 10°F of refrigerant sub-cooling.

d. Coils shall be hydrogen or helium leak tested.

e. Condenser fans shall be high efficiency electrically commutated motor driven with factory installed head pressure control module. Condenser airflow shall continuously modulate based on head pressure and cooling operation shall be allowed down to 35°F with adjustable compressor lockout.

I. Gas Heating

1. Stainless steel heat exchanger furnace shall carry a 25 year non-prorated warranty, from the date of original equipment shipment from the factory.

2. Gas furnace shall consist of stainless steel heat exchangers with multiple concavities, an induced draft blower and an electronic pressure switch to lockout the gas valve until the combustion chamber is purged and combustion airflow is established.

3. Furnace shall include a gas ignition system consisting of an electronic igniter to a pilot system, which will be continuous when the heater is operating, but will shut off the pilot when heating is not required.

4. Unit shall include a single gas connection and have gas supply piping entrances in the unit base for through-the-curb gas piping and in the outside cabinet wall for across the roof gas piping.

5. High Turndown Modulating Natural Gas Furnace shall be equipped with modulating gas valves, adjustable speed combustion blowers, stainless steel tubular heat exchangers, and electronic controller. Combustion blowers and gas valves shall be capable of modulation. Electronic controller includes a factory wired, field installed supply air temperature sensor. Sensor shall be field installed in the supply air ductwork. Supply air temperature setpoint shall be adjustable on the electronic controller within the controls compartment. Gas heater shall be capable of capacity turndown ratio as shown on the unit rating sheet. Heat trace shall be include on the condensate drain line.

J. Filters

1. Unit shall include 4 inch thick, pleated panel filters with an ASHRAE MERV rating of 13, upstream of the cooling coil. Unit shall also include 2 inch thick, pleated panel pre filters with an ASHRAE MERV rating of 8, upstream of the 4 inch standard filters.

K. Outside Air/Economizer

1. Unit shall include 0-100% economizer consisting of a motor operated outside air damper and return air damper assembly constructed of extruded aluminum, hollow core, airfoil blades with rubber edge seals and aluminum end seals. Damper blades shall be gear driven and designed to have no more than 20 cfm of leakage per sq ft. at 4 in. w.g. air pressure differential across the damper. Low leakage dampers shall be Class 2 AMCA certified, in accordance with AMCA Standard 511. Damper assembly shall be controlled by spring return enthalpy activated fully modulating actuator. Unit shall include outside air opening bird screen, outside air hood, and relief dampers.

2. Economizer shall be furnished with return air CO2 override.

L. Energy Recovery

1. Unit shall contain a factory mounted and tested energy recovery wheel. The energy recovery wheel shall be mounted in a rigid frame containing the wheel drive motor, drive belt, wheel seals and bearings. Frame shall slide out for service and removal from the cabinet.

2. The energy recovery component shall incorporate a rotary wheel in an insulated cassette frame complete with seals, drive motor and drive belt.

3. The energy recovery cassette shall be an Underwriters Laboratories Recognized Component for electrical and fire safety. The wheel drive motor shall be an Underwriters Laboratory Recognized Component and shall be mounted in the cassette frame and supplied with a service connector or junction box. Thermal performance shall be certified by the manufacturer in accordance with ASHRAE Standard 84, Method of Testing Air-to-Air Heat Exchangers and AHRI Standard 1060, Rating Air-to-Air Energy Recovery Ventilation Equipment. Cassettes shall be listed in the AHRI Certified Products.

4. Energy recovery wheel cassette shall carry a 5 year non-prorated warranty, from the date of original equipment shipment from the factory. The 5 year warranty applies to all parts and components of the cassette, with the exception of the motor, which shall carry an 18 month warranty. Warranty shall cover material and workmanship that prove defective, within the specified warranty period, provided the Airxchange written instructions for Installation, Operation, and Maintenance have been followed. Warranty excludes parts associated with routine maintenance, such as belts. Refer to the Airxchange Energy Recovery Cassette Limited Warranty Certificate.

5. Unit shall include 2 inch thick, pleated panel outside air filters with an ASHRAE

MERV rating of 8, upstream of the wheels.

6. Hinged service access doors shall allow access to the wheel.

a. Polymer Energy Recovery Wheels

1. Shall be provided with removable energy transfer matrix. Wheel frame construction shall be a welded hub, spoke and rim assembly of stainless, plated and/or coated steel and shall be self-supporting without matrix segments in place. Segments shall be removable without the use of tools to facilitate maintenance and cleaning. Wheel bearings shall be selected to provide an L-10 life in excess of 400,000 hours. Rim shall be continuous rolled stainless steel and the wheel shall be connected to the shaft by means of taper locks.

2. All diameter and perimeter seals shall be provided as part of the cassette assembly and shall be factory set. Drive belts of stretch urethane shall be provided for wheel rim drive.

3. Total energy recovery wheels shall be coated with silica gel desiccant permanently bonded by a process without the use of binders or adhesives, which may degrade desiccant performance. The substrate shall be lightweight polymer and shall not degrade nor require additional coatings for application in marine or coastal environments. Coated segments shall be washable with detergent or alkaline coil cleaner and water. Desiccant shall not dissolve nor deliquesce in the presence of water or high humidity.

M. Controls

1. Factory Installed and Factory Provided Controller

a. Unit controller shall be capable of controlling all features and options of the unit. Controller shall be factory installed in the unit controls compartment and factory tested. Controller shall be capable of standalone operation with unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling available without dependence on a building management system.

b. Controller shall have an onboard clock and calendar functions that allow for occupancy scheduling.

c. Controller shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.

e. Unit configuration, setpoint adjustment, sensor status viewing, unit alarm viewing, and occupancy scheduling shall be accomplished with connection to interface module with LCD screen and input keypad, interface module with touch screen, or with connection to PC with free configuration software. Controller shall be capable of connection with other factory installed and factory provided unit controllers with individual unit configuration, setpoint

adjustment, sensor status viewing, and occupancy scheduling available from a single unit. Connection between unit controllers shall be with a modular cable. Controller shall be capable of communicating and integrating with a BACnet network.

N. Accessories

1. Unit shall be provided with a safety shutdown terminal block for field installation of a smoke detector which shuts off the unit's control circuit.
2. Return air temperature sensor
3. Discharge air temperature sensor (to be installed on supply air duct)
4. Outside air temperature sensor
5. Return air enthalpy sensor
6. Outside air enthalpy sensor
7. Dirty filter on/off switch
8. Building static pressure sensor

O. Roof Curb (for RTU-2 A and B)

1. Horizontal Discharge Roof Curbs are by the unit manufacturer
2. 40” high to allow for supply and return air openings
3. All supply and return air openings to be provided by the manufacturer
4. Constructed from heavy 14 gauge galvanized steel
5. Construction is fully welded
6. Internally insulated 1” thick
7. Lifting lugs
8. Full perimeter wood nailer
9. Gasket shall be provided for field mounting between the unit base and roof curb.

Part 3 - Execution

3.01 Installation, Operation, and Maintenance

A. Install units in accordance with manufacturers instructions and as indicated.

B. Maintain service clearances as required.

C. Start-up and adjusting services shall be provided by qualified manufacturer's technicians. Provide start-up reports at project completion as part of closeout documents.

D. Provide a trapped cooling coil drain; Min. trap depth to be 2".

E. Provide a new set of filters at job completion. Filters to be supplied by unit manufacturer.

F. Control wiring outside the units shall be by the Mechanical Contractor. Controls integrated within the unit by the unit manufacturer.

1 General

1.1 **GENERAL**

.1 This section of the specification shall be read in conjunction with and be governed by the requirements of Section 15010.

1.2 **PRODUCT DATA**

.1 Submit product data in accordance with Section 15010.

.2 Indicate the following.
.1 Fire dampers.
.2 Fire Stop Flaps.
.3 Operators.
.4 Fusible links.
.5 Maintenance data.

1.3 **MAINTENANCE DATA**

.1 Provide maintenance data for incorporation into maintenance manual specified in Section 15010.

1.4 **MAINTENANCE MATERIALS**

.1 Provide maintenance materials in accordance with Section 15010.

1.5 **CERTIFICATION OF RATINGS**

.1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

2 Products

2.1 **FIRE DAMPERS**

.1 Galvanized steel, interlocking blade type, UL listing and label, 1 1/2 hour rating, 70 degrees C (160 degrees F) fusible line, 100 percent free opening with no part of the blade stack or damper frame in the air stream.

.2 Fire dampers in wet air exhaust shall be of stainless steel construction, all others may be galvanized steel.

.3 Provide sleeves and mounting angles, minimum 1.9 mm (14 gage), required to provide installation equivalent to the damper manufacturer's UL test installation.

.4 Submit manufacturer's installation instructions conforming to ULC rating test.

.5 Combination fire and smoke dampers: Multi louver or curtain type units meeting all requirements of both dampers shall be used where shown and may be used at the Contractor's option where applicable.

.6 Standard of Acceptance: Nailor, Ruskin

2.2 **FIRE STOP FLAPS**

.1 To be ULC listed, labelled and fire tested in accordance with CAN4-S112.2

.2 Constructed of minimum 1.5 mm thick sheet steel with 1.6 mm thick non-asbestos ULC listed insulation and corrosion resistant pins and hinges.

.3 Flaps to be held open with fusible link confirming to ULC-S505 and close at 75 C.

3 Execution

3.1 **INSTALLATION**

.1 Install fire dampers in accordance with NFPA 90A-1981.

.2 Install fire dampers complete with adjacent access door as required to permit re-opening of damper and replacement of fusible link.

.3 Maintain integrity of fire wall and/or fire separation.

.4 After completion and prior to concealment obtain approvals of complete installation.

.5 Provide fire stop flaps on any grilles penetrating fire-rated ceilings.

.6 Provide fire damper in any duct passing through a fire-rated wall or floor. Refer to architectural drawings for all fire rated wall locations.

- END -

1 General

1.1 **GENERAL**

.1 This section of the specification shall be read in conjunction with and be governed by the requirements outlined in section 15010.

1.2 **SHOP DRAWINGS AND PRODUCT DATA**

.1 Submit shop drawings and product data in accordance with Section 15010.

1.3 **SAMPLES**

.1 Submit samples in accordance with Section 15010.

.2 Submit samples for the following:

1.4 **MANUFACTURED ITEMS**

.1 Grilles, registers and diffusers shall be product of one manufacturer for generic type, ie grilles and registers by one, diffusers by one, or same.

1.5 **CERTIFICATION OF RATINGS**

.1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by him from independent testing agency signifying adherence to codes and standards.

2 Products

2.1 **GENERAL**

.1 Provide standard product to meet capacity, throw, noise level, throat and outlet velocity.

.2 Where grilles, registers and diffusers penetrate fire walls and fire partitions, provide approved steel sleeve secured to structure in accordance with NFPA 90A-1993 and required fire damper.

.3 Frames:

.1 Steel: primed cold rolled steel with exposed welded joints and mitred corners.
.2 Aluminum: extruded satin finish with mechanical fasteners and mitred corners.
.3 Provide full perimeter gaskets.
.4 Provide plaster frames as plaster stops where set into plaster or gypsum board.
.5 Provide concealed fasteners and balancing operators in all finished areas.
.6 Final finish to be selected by Architect from standard manufacturer finishes

at shop drawing stage.

.7 Style, frame, and installation details as indicated.

.4 Sizes and capacities: as indicated in the schedule.

.5 Standard of Acceptance: E.H. Price, Titus, Tittley Baily, Krugger

2.2 **Type**

.1 For grille/register/diffuser type and size, refer to equipment schedule on mechanical drawings.

3 Execution

3.1 **INSTALLATION**

.1 Install in accordance with manufacturers instructions.

.2 Contractor is responsible for selecting mounting type based on ceiling type.

.3 All diffusers and grilles in finished areas to have concealed mounting. In unfinished areas and where grilles or diffusers are to be installed in ductwork, install with bulkheads tight to either side. Site measure for exact fit.

.4 Final locations of diffusers and grilles to be in accordance with details of Architect's reflected ceiling plan. Coordinate with lighting fixtures installation by Div. 16

.5 Install and adjust air registers to provide noiseless and draftless distribution. Primary air balance to be done at duct dampers with final adjustment only at diffusers and grilles.

- END -

PART 1 - GENERAL

1.1. GENERAL

1.1.1. System Description

1.1.1.1. The air conditioning system shall be a split system with Variable Compressor Speed Inverter Technology (VCSI), charged with R410A refrigerant.

1.1.1.2. The Y-Series system shall consist of PUHY outdoor unit, multiple indoor units, and M-NET DDC (Direct Digital Controls). The sum of connected capacity of all indoor air handlers shall range from 50% to 130% of outdoor rated capacity.

1.2. DEFINITIONS:

1.2.1. Energy Efficiency Ratio (EER): The ratio of net cooling capacity is Btu/h to total rate of electricity input in watts under designated operating conditions (Btu hour/Watt).

1.2.2. Seasonal Energy Efficiency Ratio (EER): The ratio of the total cooling output of an air conditioner during its normal annual usage period for cooling in Btu/h divided by total electric energy input in watts during the same period (Btu hour/Watt).

1.3. RELATED WORK

1.3.1. Sections 15005, 15010
1.3.2. Section 15705, REFRIGERANT PIPING
1.3.3. Section 15900 Digital Control

1.4. SUBMITTALS

1.4.1. Submit in accordance with specification Section 15010, SHOP DRAWINGS AND PRODUCT DOCUMENTATION

1.4.2. Manufacturer's literature and data:

1.4.2.1. Sufficient information, including capacities, pressure drops and piping connections clearly presented, shall be included to determine compliance with drawings and specifications

1.4.2.2. Unit Dimensions required clearances, operating weights accessories and start-up instructions.

1.4.2.3. Electrical requirements, wiring diagrams, interlocking and control wiring showing factory installed and portions to be field installed.

1.4.2.4. Mounting and flashing of the roof curb to the roofing structure with coordinating requirements for the roof membrane system.

1.4.3. Certification: Submit proof of specified ARI Certification.

1.4.4. Performance Rating: Submit catalog selection data showing equipment ratings and compliance with required sensible-to-heat-ratio, energy efficiency ratio (EER), and coefficient of performance (COP).

1.4.5. Operating and Maintenance Manual: Submit three copies of Operating and Maintenance manual to Consultant two weeks prior to final inspection.

1.4.6. Completed System Readiness Checklists provided by the Commissioning Agent and completed by the contractor, signed by a qualified technician and dated on the date of completion

1.5. **QUALITY ASSURANCE**

1.5.1. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.

1.5.2. All wiring shall be in accordance with the Canadian Electrical Code.

1.5.3. The units shall be rated in accordance with ARI Standard 210 and bear the ARI label.

1.5.4. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which are a set of standards applying to environmental protection set by the International Standard Organization (ISO).

1.5.5. A full charge of R410A and oil for the required length of refrigerant tubing shall be provided in the condensing unit.

1.5.6. A dry air holding charge shall be provided in the evaporator.

1.5.7. System efficiency shall meet or exceed 19.0 SEER and 10.6 HSPF.

1.6. **DELIVERY, STORAGE AND HANDLING**

1.6.1. Unit shall be stored and handled according to the manufacturer's recommendation.

1.6.2. The controller shall be shipped inside the carton with the indoor unit and able to withstand 40.5°C (105°F) storage temperatures and 95% relative humidity.

1.7. **CONTROLS**

1.7.1. The control system shall consist of a low voltage communication network of unitary built-in controllers with on-board communications and a web-based operator interface. A web controller with a network interface card shall gather data from this system and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.

1.7.2. System controls and control components shall be installed in accordance with the manufacturer's written installation instructions.

1.7.3. Furnish energy conservation features such as optimal start, night setback, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.

1.7.4. System shall provide direct and reverse-acting on and off algorithms based on an input condition or group conditions to cycle a binary output or multiple binary outputs.

1.7.5. Provide capability for future system expansion to include monitoring and use of occupant card access, lighting control and general equipment control.

1.7.6. System shall be capable of email generation for remote alarm annunciation.

1.7.7. Control system start-up shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in Mitsubishi controls system configuration and operation. The representative shall provide proof of certification for Mitsubishi CMCN Essentials Training and/or CMCN Hands-On Training indicating successful completion of no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals. This service shall be equipment and system count dependent and shall be a minimum of one (1) eight (8) hour period to be completed during normal working hours.

1.8. **WARRANTY**

1.8.1. The units shall have a manufacturer's warranty for a period of five (5) years from date of installation.

1.8.2. The compressor shall have a warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer.

1.8.3. This warranty does not include labour. Manufacturer shall have twenty years experience in the Canadian market.

1.9. **PERFORMANCE**

1.9.1. Each system shall perform in accordance to the ratings shown in the equipment schedules.

1.9.2. Performance shall be based on 26.7°DBT, 19.4°WBT (80°DBT, 67°WBT) for the indoor unit and 35°CDBT, 23.9°CWBT (95°FDBT, 75°FWBT) for the outdoor unit.

1.10. **STANDARD OF ACCEPTANCE**

1.10.1. Indoor units Base of Design:

1.10.1.1. Mitsubishi PKFY - P series, wall mounted, capacity as noted on the equipment schedules

1.10.1.2. Mitsubishi PLFY-P series, cassette style, capacity as noted in the equipment schedules

1.10.2. Outdoor units base of design: Mitsubishi PUHY – P series, capacity as noted on the equipment schedules

1.10.3. Alternate manufacturer: Daikin

PART 2 - PRODUCTS

2.1. **INDOOR UNITS**

2.1.1. General

2.1.1.1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, internal piping, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dry air before shipment from the factory.

2.2. **PKFY (WALL MOUNTED) INDOOR UNIT**

2.2.1. General:

2.2.1.1. The PKFY shall be a wall-mounted indoor unit section and shall have a modulating linear expansion device and a flat front. The PKFY shall be used with the R2-Series outdoor unit and BC Controller, Y-Series outdoor unit, or S-Series outdoor unit. The PKFY shall support individual control using M-NET DDC controllers.

2.2.2. Indoor Unit

2.2.2.1. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

2.2.3. Unit Cabinet:

2.2.3.1. All casings, regardless of model size, shall have the same white finish
2.2.3.2. Multi directional drain and refrigerant piping offering four (4) directions for refrigerant piping and two (2) directions for draining shall be standard.
2.2.3.3. There shall be a separate back plate which secures the unit firmly to the wall.

2.2.4. Fan:

2.2.4.1. The indoor fan shall be an assembly with one or two line-flow fan(s) direct driven by a single motor.
2.2.4.2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
2.2.4.3. A manual adjustable guide vane shall be provided with the ability to change the airflow from side to side (left to right).
2.2.4.4. A motorized air sweep louver shall provide an automatic change in airflow by directing the air up and down to provide uniform air distribution.

2.2.5. Filter:

2.2.5.1. Return air shall be filtered by means of an easily removable, washable filter.

2.2.6. Coil:

2.2.6.1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2.2.6.2. The tubing shall have inner grooves for high efficiency heat exchange.
2.2.6.3. All tube joints shall be brazed with phos-copper or silver alloy.
2.2.6.4. The coils shall be pressure tested at the factory.
2.2.6.5. A condensate pan and drain shall be provided under the coil.
2.2.6.6. Both refrigerant lines to the PKFY indoor units shall be insulated in accordance with the installation manual.

2.2.7. Electrical:

2.2.7.1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2.2.7.2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz)

2.2.8. Controls:

2.2.8.1. This unit shall use controls provided by Mitsubishi Electric Cooling & Heating to perform functions necessary to operate the system. Please refer to Part 4 of this guide specification for details on controllers and other control options.
2.2.8.2. The unit shall be able to control external backup heat.
2.2.8.3. The unit shall have a factory built in receiver for wireless remote control
2.2.8.4. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
2.2.8.5. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
2.2.8.6. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
2.2.8.7. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

2.3. **PLFY-EP**NEMU-E* (4-WAY CEILING-RECESSED CASSETTE WITH GRILLE) INDOOR UNIT**

2.3.1. General

2.3.1.1. The PLFY-EP**NEMU-E* shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall

be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function, a test run switch, and the ability to adjust airflow patterns for different ceiling heights. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

2.3.2. Unit Cabinet:

2.3.2.1. The cabinet shall be space-saving ceiling-recessed cassette.
2.3.2.2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
2.3.2.3. Branch ducting shall be allowed from cabinet.
2.3.2.4. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.
2.3.2.5. The grille vane angles shall be individually adjustable from the wired remote controller to customize the airflow pattern for the conditioned space

2.3.3. Fan:

2.3.3.1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2.3.3.2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
2.3.3.3. The indoor fan shall consist of five (5) speed settings, Low, Mid1, Mid2, High and Auto.
2.3.3.4. The fan shall have a selectable Auto fan setting that will adjust the fan speed based on the difference between controller set-point and space temperature.
2.3.3.5. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
2.3.3.6. The indoor unit shall have switches that can be set to provide optimum airflow based on ceiling height and number of outlets used.
2.3.3.7. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution.
2.3.3.8. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space.
2.3.3.9. If specified, the grille shall have an optional i-see sensor that will measure room temperature variations and adjust the airflow accordingly to evenly condition the space.

2.3.4. Filter:

2.3.4.1. Return air shall be filtered by means of a long-life washable filter

2.3.5. Coil:

2.3.5.1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2.3.5.2. The tubing shall have inner grooves for high efficiency heat exchange.
2.3.5.3. All tube joints shall be brazed with phos-copper or silver alloy.
2.3.5.4. The coils shall be pressure tested at the factory.
2.3.5.5. A condensate pan and drain shall be provided under the coil.
2.3.5.6. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 33 inches above the condensate pan.
2.3.5.7. Both refrigerant lines to the PLFY indoor units shall be insulated in accordance with the installation manual.

2.3.6. Electrical:

2.3.6.1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.
2.3.6.2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

2.3.7. Controls:

2.3.7.1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system.
2.3.7.2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.
2.3.7.3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.
2.3.7.4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.
2.3.7.5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

2.4. **PLFY-P**NFMU (4-WAY CEILING-RECESSED CASSETTE WITH GRILLE) INDOOR UNIT**

2.4.1. General:

2.4.1.1. The PLFY-P**NFMU shall be a four-way cassette style indoor unit that recesses into the ceiling with a ceiling grille. The indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function and a test run switch. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory.

2.4.2. Unit Cabinet:

2.4.2.1. The cabinet shall be a compact 22-7/16” wide x 22-7/16” deep so it will fit within a standard 24” square suspended ceiling grid.
2.4.2.2. The cabinet panel shall have provisions for a field installed filtered outside air intake.
2.4.2.3. Four-way grille shall be fixed to bottom of cabinet allowing two, three or four-way blow.

2.4.3. Fan:

2.4.3.1. The indoor fan shall be an assembly with a turbo fan direct driven by a single motor.
2.4.3.2. The indoor fan shall be statically and dynamically balanced to run on a motor with permanently lubricated bearings.
2.4.3.3. The indoor fan shall consist of three (3) speeds, Low, Mid, and High.
2.4.3.4. The indoor unit shall have an adjustable air outlet system offering 4-way airflow, 3-way airflow, or 2-way airflow.
2.4.3.5. The auto air swing vanes shall be capable of automatically swinging up and down for uniform air distribution.

2.4.4. Filter:

2.4.4.1. Return air shall be filtered by means of a long-life washable filter.

2.4.5. Coil:

2.4.5.1. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing.
2.4.5.2. The tubing shall have inner grooves for high efficiency heat exchange.
2.4.5.3. All tube joints shall be brazed with phos-copper or silver alloy.
2.4.5.4. The coils shall be pressure tested at the factory.

2.4.5.5. A condensate pan and drain shall be provided under the coil.

2.4.5.6. The unit shall be provided with an integral condensate lift mechanism that will be able to raise drain water 19-3/4" inches above the condensate pan.

2.4.5.7. Both refrigerant lines to the PLFY indoor units shall be insulated in accordance with the installation manual.

2.4.6. Electrical:

2.4.6.1. The unit electrical power shall be 208/230 volts, 1-phase, 60 hertz.

2.4.6.2. The system shall be capable of satisfactory operation within voltage limits of 187-228 volts (208V/60Hz) or 207-253 volts (230V/60Hz).

2.4.7. Controls:

2.4.7.1. This unit shall use controls provided by Mitsubishi Electric to perform functions necessary to operate the system.

2.4.7.2. Indoor unit shall compensate for the higher temperature sensed by the return air sensor compared to the temperature at level of the occupant when in HEAT mode. Disabling of compensation shall be possible for individual units to accommodate instances when compensation is not required.

2.4.7.3. Control board shall include contacts for control of external heat source. External heat may be energized as second stage with 1.8°F – 9.0°F adjustable deadband from set point.

2.4.7.4. Indoor unit shall include no less than four (4) digital inputs capable of being used for customizable control strategies.

2.4.7.5. Indoor unit shall include no less than three (3) digital outputs capable of being used for customizable control strategies.

2.5. **OUTDOOR UNIT – PUHY SERIES**

2.5.1. General

2.5.1.1. The Y-Series PUHY outdoor unit shall be specifically used with CITY MULTI VRF components. The PUHY outdoor units shall be equipped with multiple circuit boards that interface to the M-NET controls system and shall perform all functions necessary for operation. Each outdoor unit module shall be completely factory assembled, piped, wired and run tested at the factory.

2.5.1.2. The model nomenclature and unit requirements are shown below. All units requiring a factory supplied twinning kit shall be piped together in the field, without the need for equalizing line(s). If an alternate

manufacturer is selected, any additional material, cost, and labor to install additional lines shall be incurred by the contractor.

2.5.1.3. Modular variable refrigerant flow (VRF) systems; smaller capacity units can be piped together to form a single, large-capacity two-pipe system. Refer to the table below.

Outdoor Unit Model Nomenclature		
POWER AS PER EQUIPMENT SCHEDULE		**Twinning Kit**
Model Number	**Units**	
PUHY-P72ZKMU	(1) PUHY-P72ZKMU	None
PUHY-P96ZKMU	(1) PUHY-P96ZKMU	None
PUHY-P120ZKMU	(1) PUHY-P120ZKMU	None
PUHY-P144ZKMU	(1) PUHY-P144ZKMU	None
PUHY-PP168ZSKMU	(1) PUHY-P96ZKMU (1) PUHY-P72ZKMU	CMY-Y100CBK3
PUHY-P192ZSKMU	(1) PUHY-P120ZKMU (1) PUHY-P72ZKMU	CMY-Y100CBK3
PUHY-P216ZSKMU	(1) PUHY-P96ZKMU (1) PUHY-P120ZKMU	CMY-Y100CBK3

2.5.1.4. Outdoor unit shall have a sound rating no higher than 60 dB(A) individually or 65 dB(A) twinned. Units shall have a sound rating no higher than 50 dB(A) individually or 55 dB(A) twinned while in night mode operation. If an alternate manufacturer is selected, any additional material, cost, and labor to meet published sound levels shall be incurred by the contractor.

2.5.1.5. Outdoor unit shall be able to connect to up to 50 indoor units depending upon model.

2.5.1.6. Both refrigerant lines from the outdoor unit to indoor units shall be insulated.

2.5.1.7. The outdoor unit shall have an accumulator with refrigerant level sensors and controls.

2.5.1.8. The outdoor unit shall have a high pressure safety switch, over-current protection and DC bus protection.

2.5.1.9. The outdoor unit shall have the ability to operate with a maximum height difference of 164 feet (294 feet optional) and have a total refrigerant tubing length of 3280 feet. The greatest length is not to exceed 541 feet between the outdoor unit and the indoor units without the need for line size changes or traps.

2.5.1.10. The outdoor unit shall be capable of operating in heating mode down to -4□F ambient temperature or cooling mode down to 23□F ambient temperature, without additional low ambient controls. If an alternate manufacturer is selected, any additional material, cost, and labor to meet low ambient operating condition and performance shall be incurred by the contractor.

2.5.1.11. The outdoor unit shall be capable of operating in cooling mode down to -10□F with optional manufacturer supplied low ambient kit.

2.5.1.12. Manufacturer supplied low ambient kit shall be provided with predesigned control box rated for outdoor installation and capable of controlling kit operation automatically in all outdoor unit operation modes.

2.5.1.13. Manufacturer supplied low ambient kit shall be listed by Electrical Laboratories (ETL) and bear the ETL label.

2.5.1.14. Manufacturer supplied low ambient kit shall be factory tested in low ambient temperature chamber to ensure operation. Factory performance testing data shall be available when requested.

2.5.1.15. The outdoor unit shall be provided with a manufacturer supplied 20 gauge hot dipped galvanized snow /hail guard. The snow/hail guard protects the outdoor coil surfaces from hail damage and snow build-up in severe climates.

2.5.1.16. The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained.

2.5.2. Unit Cabinet:

2.5.2.1. The casing(s) shall be fabricated of galvanized steel, bonderized and finished. Units cabinets shall be able to withstand 960 hours per ASTM B117 criteria for seacoast protected models (–BS models).

2.5.3. Fan:

2.5.3.1. Each outdoor unit module shall be furnished with one direct drive, variable speed propeller type fan.

2.5.3.2. The fan motor shall have inherent protection, have permanently lubricated bearings, and be completely variable speed. The fan shall be factory set for operation under 0 in. WG external static pressure, but capable of normal operation under a maximum of 0.24 in. WG external static pressure via dipswitch.

2.5.3.3. The fan motor shall be mounted for quiet operation.

2.5.3.4. The fan shall be provided with a raised guard to prevent contact with moving parts.

2.5.3.5. The outdoor unit shall have vertical discharge airflow.

2.5.4. Refrigerant

2.5.4.1. R410A refrigerant shall be required for PUHY-T/Y(S)KMU-A outdoor unit systems.

2.5.4.2. Polyolester (POE) oil shall be required. Prior to bidding, manufacturers using alternate oil types shall submit material safety data sheets (MSDS) and comparison of hygroscopic properties for alternate oil with list of local suppliers stocking alternate oil for approval at least two weeks prior to bidding.

2.5.5. Coil:

2.5.5.1. The outdoor coil shall be of nonferrous construction with lanced or corrugated plate fins on copper tubing.

2.5.5.2. The coil fins shall have a factory applied corrosion resistant blue-fin finish.

2.5.5.3. The coil shall be protected with an integral metal guard.

2.5.5.4. Refrigerant flow from the outdoor unit shall be controlled by means of an inverter driven compressor.

2.5.5.5. The outdoor coil shall include 4 circuits with two position valves for each circuit, except for the last stage.

2.5.6. Compressor:

2.5.6.1. Each outdoor unit module shall be equipped with one inverter driven scroll hermetic compressor. Non inverter-driven compressors, which cause inrush current (demand charges) and require larger wire sizing, shall not be allowed.

2.5.6.2. A crankcase heater(s) shall be factory mounted on the compressor(s).

2.5.6.3. The outdoor unit compressor shall have an inverter to modulate capacity. The capacity shall be completely variable with an operating range of 5% ~ 100% depending upon unit capacity, operation, and configuration.

2.5.6.4. The compressor shall be equipped with an internal thermal overload.

2.5.6.5. The compressor shall be mounted to avoid the transmission of vibration.

2.5.7. Controls:

2.5.7.1. The outdoor unit shall have the capability of up to 8 levels of demand control for each refrigerant system

2.5.8. Electrical:

2.5.8.1. The outdoor unit electrical power shall be as noted on the equipment schedules.

2.5.8.2. The outdoor unit shall be capable of satisfactory operation within voltage limits of +/- 10% volts variance from the value noted in the equipment schedules.

2.5.8.3. The outdoor unit shall be controlled by integral microprocessors.

2.5.8.4. The control circuit between the indoor units, BC Controller and the outdoor unit shall be 24VDC completed using a 2-conductor, twisted pair shielded cable to provide total integration of the system.

2.6. **OUTDOOR UNITS – PUMY SERIES**

2.6.1. The outdoor unit will be constructed from steel plate and painted with acrylic paint Munsel 3Y 7.8/1.1.

2.6.2. Performance and capacity: as indicated on the equipment schedules

2.6.3. The outdoor unit will have air-cooled heat exchanger coils constructed from copper tubing with aluminum fins. The coil will be set in an “L” formation with aire being drawn in through front of unit and discharge out of the back of the unit. The outdoor unit will have two fans each mounted on the front of the coil. The coils will be capable of being dividing into 20,30,50,70,80,100 % sections to enable the outdoor unit capacity to match the capacity required by the indoor units.

2.6.4. The outdoor unit will have one inverter controlled hermetic scroll compressor capable of controlling the compressor frequency in 1Hz increments.

2.6.5. The refrigeration process of the outdoor unit will be maintained by pressure and temperature sensors controlling solenoid valves, check valves and bypass valves. The heating or cooling mode of the outdoor unit will be controlled by a 4 way valve which will reverse the cycle of the refrigerant to change the mode of the outdoor unit. Condensate shall be removed from the S-Series by means of a drain pipe connector located on the bottom of unit.

2.6.6. The outdoor unit will have one liquid discharge pipe which will supply high pressure liquid to the indoor units or to the condensing unit, depending on the mode of operation. Refrigerant return to the outdoor unit will be via one suction pipe. Both pipes shall be insulated.

2.6.7. The system will be capable of total pipe runs of up to 120m.

2.6.8. The system(s) will have the following nominal capacity and Outdoor unit pipe sizes:-

2.6.9. The outdoor unit will require a 208-230 vac single phase power supply and have a starting current of no more than 10 amps. Control will be via a 30vdc signal generated by the outdoor unit. This signal will be sent to the indoor units via a 16 AWG 2 core non polar screened cable.

2.7. **CONTROLS**

2.7.1. General:

2.7.1.1. The CITY MULTI Controls Network (CMCN) shall be capable of supporting remote controllers, centralized controllers, an integrated web based interface, graphical user workstation, and system integration to Building Management Systems via BACnet®

2.7.2. Electrical Characteristics

2.7.2.1. General:

2.7.2.1.1. The CMCN shall operate at 30VDC. Controller power and communications shall be via a common non-polar communications bus.

2.7.2.2. Wiring:

2.7.2.2.1. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.

2.7.2.2.2. Control wiring for the Smart ME remote controller shall be from the remote controller to the first associated indoor unit (TB-5) M-NET connection. The Smart ME remote controller shall be assigned an M-NET address.

2.7.2.2.3. Control wiring for the Simple MA and Wireless MA remote controllers shall be from the remote controller (receiver) to the first associated indoor unit (TB-15) then to the remaining associated indoor units (TB-15) in a daisy chain configuration.

2.7.2.2.4. Control wiring for centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to the system controllers (centralized controllers and/or integrated web based interface), to the power supply.

2.7.2.2.5. The AE-200, AE-50, and EB-50GU centralized controller shall be capable of being networked with other AE-200, AE-50, and EB-50GU centralized controllers for centralized control.

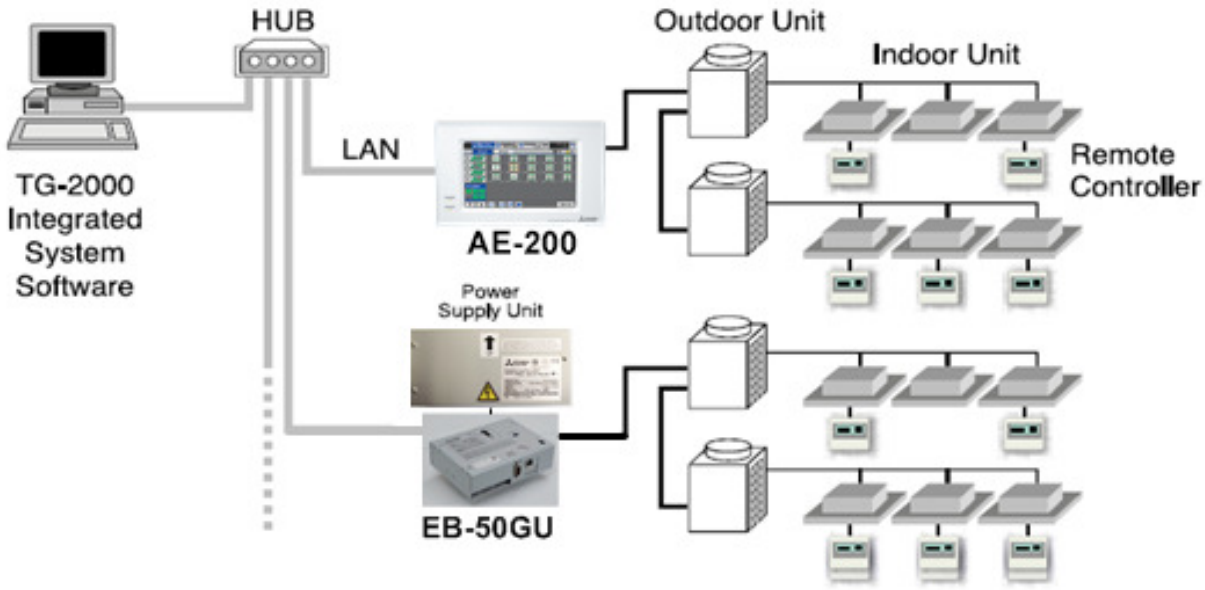
2.7.2.3. Wiring type:

2.7.2.3.1. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire as defined by the Diamond System Builder output.

2.7.2.3.2. Network wiring shall be CAT-5 with RJ-45 connection.

2.7.3. CITY MULTI Controls Network

2.7.3.1. The CITY MULTI Controls Network (CMCN) consists of remote controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The CITY MULTI Controls Network shall support operation monitoring, scheduling, occupancy, error email distribution, personal web browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces. The below figure illustrates a sample CMCN System Configuration.



2.7.4. CMCN: Remote Controllers

2.7.4.1. Backlit Simple MA Remote Controller (PAC-YT53CRAU)

2.7.4.1.1. The Backlit Simple MA Remote Controller (PAC-YT53CRAU) shall be capable of controlling up to 16 indoor units (defined as 1 group). The Backlit Simple MA Remote Controller shall be compact in size, approximately 3” x 5” and have limited user functionality. The Backlit Simple MA supports temperature display selection of Fahrenheit or Celsius. The Backlit Simple MA Remote Controller shall allow the user to change on/off, mode (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, and fan speed setting and airflow direction. The Backlit Simple MA Remote Controller shall be able to limit the set temperature range from the Backlit Simple MA. The Backlit Simple MA Remote controller shall be capable of night setback control with upper and lower set temperature settings. The room temperature shall be sensed at either the Backlit Simple MA Remote Controller or the Indoor Unit dependent on the

indoor unit dipswitch setting. The Backlit Simple MA Remote Controller shall display a four-digit error code in the event of system abnormality/error.

2.7.4.1.2. The Backlit Simple MA Remote Controller shall only be used in same group with Wireless MA Remote Controllers (PAR-FL32MA-E / PAR-FA32MA-E) or with other Backlit Simple MA Remote Controllers (PAC-YT53CRAU), with up to two remote controllers per group.

2.7.4.1.3. The Backlit Simple MA Remote Controller shall require no addressing. The Backlit Simple MA Remote Controller shall connect using two-wire, stranded, non-polar control wire to TB15 connection terminal on the indoor unit. The Simple MA Remote Controller shall require cross-over wiring for grouping across indoor units.

PAC-YT53CRAU (Backlit Simple MARemote Controller)			
Item	**Description**	**Operation**	**Display**
ON/OFF	Run and stop operation for a single group	Each Group	Each Group
Operation Mode	Switches between Cool/Drying/Auto/Fan/Heat/Setback. Operation modes vary depending on the air conditioner unit. Auto and Setback mode are available for the R2/WR2-Series only.	Each Group	Each Group
Temperature Setting	Sets the temperature from 40°F – 95°F depending on operation mode and indoor unit. Separate COOL and HEAT mode set points available depending on central controller and connected mechanical equipment.	Each Group	Each Group
Fan Speed Setting	Available fan speed settings depending on indoor unit.	Each Group	Each Group
Air Flow Direction Setting	Air flow direction settings vary depending on the indoor unit model.	Each Group	Each Group
Permit / Prohibit Local Operation	Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions.	1 N/A	Each Group *1
Display Indoor Unit Intake Temp	Measures and displays the intake temperature of the indoor unit when the indoor unit is operating.	N/A	Each Group
Display Backlight	Pressing the button lights up a backlight. The light automatically turns off after a certain period of time. (The brightness settings can be selected from Bright, Dark, and Light off.)	N/A	Each Unit
Error	When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed	N/A	Each Unit
Test Run	Operates air conditioner units in test run mode. *2 The display for test run mode will be the same as for normal start/stop (does not display “test run”).	Each Group	Each Group *2
Ventilation Equipment	Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit.	Each Group	N/A

PAC-YT53CRAU (Backlit Simple MARemote Controller)			
Item	**Description**	**Operation**	**Display**
Set Temperature Range Limit	Set temperature range limit for cooling, heating, or auto mode.	Each Group	Each Group

2.7.5. Centralized Controller (Web-enabled)

2.7.5.1. AE-200 Centralized Controller

2.7.5.1.1. The AE-200A Centralized Controller shall be capable of controlling a maximum of two hundred (200) indoor units across multiple CITY MULTI outdoor units with the use of three (3) AE-50A expansion controllers. The AE-200A Centralized Controller shall be approximately 11-5/32” x 7-55/64” x 2-17/32” in size and shall be powered with an integrated 100-240 VAC power supply. The AE-200A Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. When being used alone without the expansion controllers, the AE-200A Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the AE-200 Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, fan speed setting, and airflow direction setting. Since the AE-200A provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the AE-200A Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

2.7.5.1.2. All AE-200A Centralized Controllers shall be equipped with two RJ-45 Ethernet ports to support interconnection with a network PC via a closed/direct Local Area Network (LAN) or to a network switch for IP communication to up to three AE-50A expansion controllers for

display of up to two hundred (200) indoor units on the main AE-200A interface.

2.7.5.1.3. The AE-200A Centralized Controller shall be capable of performing initial settings via the high-resolution, backlit, color touch panel on the controller or via a PC browser using the initial settings.

2.7.5.1.4. Standard software functions shall be available so that the building manager can securely log into each AE-200A via the PC's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Additional optional software functions of personal browser for PCs and MACs and Tenant Billing shall be available but are not included. The Tenant Billing function shall require TG-2000 Integrated System software in conjunction with the Centralized Controllers.

2.7.5.2. AE-50A Expansion Controller

2.7.5.2.1. The AE-50A Expansion Controller shall serve as a standalone centralized controller or as an expansion module to the AE-200A Centralized Controller for the purpose of adding up to 50 indoor units to either the main touch screen interface of the AE-200A. Up to three (3) AE-50A expansion controllers can be connected to the AE-200A via a local IP network (and their IP addresses assigned on the AE-200A) to the AE-200A to allow for up to two hundred .(200) indoor units to be monitored and controlled from the AE-200A interface.

2.7.5.2.2. The AE-50A expansion controllers have all of the same capabilities to monitor and control their associated indoor units as the features specified above. Even when connected to the AE-200A and configured to display their units on the main controller, the individual indoor units connected to the AE-50A can still be monitored and controlled from the interface of the AE-50. The last command entered will take precedence, whether at the wall controller, the AE-50A or the AE-200A Centralized Controller.

2.7.5.3. EB-50GU Centralized Controller

2.7.5.3.1. The EB-50GU Centralized Controller shall be capable of controlling a maximum of 50 indoor units across multiple CITY MULTI outdoor units. The EB-50GU Centralized Controller shall be approximately 8-1/2"x10" in size and shall be powered from the external power supply (PAC-SC51KUA). The EB-50GU Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback settings, free contact interlock configuration and malfunction monitoring. The EB-50GU Centralized Controller shall have five basic operation controls which can be applied to an

individual indoor unit, a group of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the EB-50GU Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, fan speed setting, and airflow direction setting. Since the EB-50GU provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the EB-50GU Centralized Controller shall allow the user to define both daily and weekly schedules with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

2.7.5.3.2. All EB-50GU Centralized Controllers shall be equipped with one RJ-45 Ethernet port to support interconnection with a network PC via a closed/direct Local Area Network (LAN).The EB-50GU Centralized Controller shall be capable of performing initial settings via a PC using the EB-50GU Centralized Controller's initial setting browser.

2.7.5.3.3. Standard software functions shall be available so that the building manager can securely log into each EB-50GU via the PC's web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Standard software functions shall not expire. Additional optional software functions of personal browser for PCs and MACs and Tenant Billing shall be available. The Tennant Billing function shall require TG-2000 Integrated System software in conjunction with EB-50GU Centralized Controllers.

2.7.5.4. The following software functions are optional per AE-200/AE-50/EB-50GU:

2.7.5.4.1. Personal Web Browser (SW-Pweb): The CMCN shall be capable of allowing up to 50 individual users to monitor and control user defined zones via a network PC or MAC's web browser.

2.7.5.4.2. Tenant Billing (SW-Charge): The CMCN shall be capable of calculating CITY MULTI energy usage in kWh and in a monetary amount based on the energy consumption of the outdoor unit(s) divided among the associated indoor units per AE-200/AE-50/EB-50GU. This software is used in conjunction with the TG-2000 software a networked PC, and Watt Hour Meters (WHM).

2.7.6. CMCN: System Integration

2.7.6.1. The CMCN shall be capable of supporting integration with Building Management Systems (BMS).

2.7.6.2. BAC-HD150: BACnet® Interface

2.7.6.3. The Mitsubishi Electric Cooling & Heating BACnet® interface, BAC-HD150, shall be compliant with BACnet® Protocol (ANSI/ASHRAE 135-2004) and be Certified by the (BTL) BACnet® Testing Laboratories. The BACnet® interface shall support BACnet Broadcast Management (BBMD). The BACnet® interface shall support a maximum of 50 indoor units. Operation and monitoring points include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, and error address.

2.7.7. Power Supply (PAC-SC51KUA)

2.7.7.1. The power supply shall supply 24VDC (TB3) for the AE-200/AE-50/EB-50GU centralized controller and 30VDC (TB2) voltage for the central control transmission.

PART 3 - INSTALLATION

3.1. REFRIGERANT PIPEWORK

3.1.1. Supply, install, test and commission all interconnecting refrigeration pipework between the outdoor and indoor units. Also refer to section 23 23 00 REFRIGERANT PIPING

3.1.2. All pipework to be carried out in refrigerant quality ACR copper tubing and complete with the appropriate headers and joints. All pipework must be suitable for R410A.

3.1.3. Longest possible lengths of copper pipe should be utilised to minimise joints on site.

3.1.4. Appropriate refrigeration installation tools must be utilized. Dry Nitrogen must be utilized at all times in the system during brazing.

3.1.5. All pipework (suction and liquid lines) to be insulated with slip on close cell elastomeric pipe insulation (as manufactured by Armaflex or equal and approved) having a wall thickness of not less that ½". Also refer to section 23 23 00 REFRIGERANT PIPING

3.1.6. After installation of pipework, and prior to sealing of insulation joints and starting of equipment, pipework should be pressure tested. 44 PSIG test for 3 minutes minimum, then 217 PSIG for 3 minimum, then 478 PSIG for 3 minutes minimum,

then strength test to 600 PSIG check the system for leaks and deformation, then lower the pressure back to 478 PSIG and pressure test for 24 hours and checked for leaks. Vacuumed/dehydrated to 300 microns, and hold at that vacuum for 12 hours (minimum)

3.1.7. Refrigerant (R410A) charge weight must be calculated, to the actual installed length of pipe work in accordance to Mitsubishi recommendations.

3.1.8. The charging should be carried out with an appropriate charging station.

3.1.9. Pipework to be properly fixed and supported at a minimum of 1.5 metres (5 feet) centres or as specified by local code and where required should be run on galvanised trays. All pipework to be labeled with ID number (condensing units ref.) at 3 metre (9 feet) intervals.

3.1.10. Joints in copper pipe shall be brazed. Brazing shall be carried out to the requirements of the local code and as per the Canadian copper & brass development association recommendations.

3.1.11. Coordinate the exact routing of refrigerant piping with existing building services and structural/architectural features of the building.

3.2. **CONDENSATE PIPEWORK**

3.2.1. A condensate line shall be installed to each fan coil unit. This shall be installed and insulated all as per the standard specification. Minimum size of condensate pipes to be 38mm (1½ inch) copper, insulated and pumped or by gravity from each fan coil/cassette, drains to run 1:80 min falls as indicated on drawings.

3.2.2. Coordinate the exact routing of condensate piping with existing building services and structural/architectural features of the building. Maintain slope as indicated.

3.3. **OUTDOOR UNIT**

3.3.1. Install outdoor in strict accordance with the manufacturer's instructions; adhere strictly to all manufacturer's instructions pertaining to clearances around the equipment and between the adjacent condensing units.

3.3.2. Secure outdoor equipment to the roof supports; for roof supports, refer to details on the drawings.

3.3.3. Connect equipment to power supply and refrigerant piping. All refrigerant piping final sizing to be calculated by the manufacturer and submitted at shop drawings stage. Calculation shall be based on the total developed length of the lines.

3.3.4. Connect equipment to the BAS and make all connections between the outdoor equipment and the indoor evaporator. Supply and install all wiring and controllers furnished by the manufacturer.

3.4. **INDOOR UNITS**

3.4.1. Install indoor units where noted on the drawings and conform strictly to the manufacturer's instructions. Coordinate location of all indoor units with the existing structural/architectural elements and where applicable, with the ceiling grid, lights and other ceiling-mounted devices.

3.4.2. Connect all refrigerant lines in accordance with the manufacturer's instructions.

3.4.3. A full load of refrigerant shall be supplied for each system, adequate for the system capacity and refrigerant lines lengths.

3.4.4. Make connections to power supply in accordance to the manufacturer's instructions.

3.4.5. Make connections to the BAS in accordance with the sequences of operations and BAS specifications.

3.4.6. Connect all evaporators to a condensate drainage loop, discharging onto the janitorial sink, as noted. Slope the drain lines as specified.

3.4.7. Coordinate the layout of the drainage with the existing radiators, heating pipes and other services. Cut out round sections through the radiator covers where required and pass in between finned elements.

3.5. **CONNECTIONS**

3.5.1. Verify condensate drainage requirements.

3.5.2. Install condensate drain, minimum connection size, with trap and indirect connection to noted discharge point.

3.5.3. Install piping adjacent to units to allow service and maintenance.

3.5.4. Ground equipment and install power wiring, switches, and controls for self contained and split systems.

3.5.5. Connect refrigerant piping to coils with shutoff valves on the suction and liquid lines at the coil and a union or flange at each connection at the coil and condenser.

3.6. **FIELD QUALITY CONTROL**

3.6.1. Perform tests and inspections and prepare test reports.

3.6.2. Tests and Inspections: After installing units and after electrical circuitry has been energized, test units for compliance with requirements. Inspect for and remove shipping bolts, blocks, and tie-down straps. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment. Remove and replace malfunctioning units and retest as specified above.

3.7. **STARTUP AND TESTING**

3.7.1. All equipment shall be inspected, started up and adjusted by the trained manufacturer's representatives.

3.7.2. The start-up and adjustment shall be closely coordinated with the BAS Vendor.

3.7.3. The Consultant will observe startup and contractor testing of selected equipment. Coordinate the startup and contractor testing schedules with the Board project Supervisor and Commissioning Agent. Provide a minimum of 7 days prior notice.

3.8. **DEMONSTRATION AND TRAINING**

3.8.1. Provide services of manufacturer's technical representative for four hours to instruct Board personnel in operation and maintenance of units.

PART 1 - GENERAL

1.1 GENERAL

1. This section of the specification shall be read in conjunction with and shall be governed by the requirements outlined in Section 15010 of the specification.

1.2 STANDARD OF ACCEPTANCE

.1 Existing building BAS is by Honeywell

1.3 GENERAL INTENT

1. The general outline of the scope of work includes but is not limited to the following:

   .1 Supply and install the new BAS components (sensors, wiring, relays, controllers, panels, etc) required to make the new air handling and split A/C equipment operate in accordance with the sequence indicated on the drawings.

   .2 Update and expand the existing programming as required to match the sequence of operation indicated on the drawings; c/w graphical displays on the Board main server to match the new equipment layout and configuration.

   .3 Provide all necessary power wiring and hardware to complete the entire project, including but not limited to, wiring, fittings, connectors, conduits, hangers/supports, box covers, BAS control panels, and all other accessories required to ensure complete, safe and fully operational systems. This shall include the power wiring for all the equipment.

   .4 Make good all surfaces affected by the work.

2. Arrange for Electrical Authority inspection of all electrical work done by the Control Sub-Contractor. Submit the Certificate of Inspection and Product Approval Certificate with the as-built documentation.

1.4 QUALITY ASSURANCE

1. Installer and Manufacturer Qualifications

   .1 Installer shall have an established working relationship with Control System Manufacturer.

   .2 Installer shall have successfully completed Control System Manufacturer's control system training. Upon request, Installer shall present record of completed training including course outlines.

   .3 The Building Automation System supplier shall be a subcontractor to Mechanical Contractor who shall be responsible for the complete installation of the controls devices and wiring and guarantee its proper function.

.4 The new controls sensors and devices shall be supplied and installed by one of the suppliers listed in these specifications. No other suppliers are acceptable, Mechanical Contractors shall name the Control supplier at the time of tender.

.5 The new DDC components serving the air handling system shall be connected via the Board's wide area network. All system functions including displays, programs and graphics shall be accessible from any personal computer on the Board's network with web browser software. The control contractor shall demonstrate to the consultant the ability to access programming and graphics remotely from a location as chosen by the consultant.

1.5 CODES AND STANDARDS

1. Work, materials, and equipment shall comply with the most restrictive of local, provincial, and federal authorities' codes and ordinances or these plans and specifications. As a minimum, the installation shall comply with current editions in effect 30 days prior to receipt of bids of the following codes:

   .1 National Electric Code (NEC)
   .2 ANSI/ASHRAE 135-2004: Data Communication Protocol for Building Automation and Control Systems (BACNET)

1.6 SYSTEM PERFORMANCE

1. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

2. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.

3. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.

4. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.

5. Object Command. Devices shall react to command of a Digital object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.

6. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 15 sec.

7. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.

8. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times

consistent with the mechanical process under control.

9. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.

10. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.

11. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed in Table 2.

Table 1 - Reporting Accuracy

Measured Variable	Reported Accuracy
Space Temperature	±0.5ºC (±1ºF)
Ducted Air	±0.5ºC (±1ºF)
Outside Air	±1.0ºC (±2ºF)
Dew Point	±1.5ºC (±3ºF)
Water Temperature	±0.5ºC (±1ºF)
Delta-T	±0.15ºC (±0.25ºF)
Water Flow	±2% of full scale
Air Pressure (ducts)	±25 Pa (±0.1 in. w.g.)
Electrical (A, V, W, Power Factor)	±1% of reading
Carbon Dioxide (CO_2)	±50 ppm

Table 2 - Control Stability and Accuracy

Controlled Variable	Control Accuracy	Range of Medium
Air Pressure	±50 Pa (±0.2 in. w.g.) ±3 Pa (±0.01 in. w.g.)	0-1.5 kPa (0-6 in. w.g.) -25 to 25 Pa (-0.1 to 0.1"wg)
Airflow	±10% of full scale	
Space Temperature	±1.0ºC (±2.0ºF)	
Duct Temperature	±1.5ºC (±3ºF)	

1.7 SUBMITTALS

1. Provide three copies of shop drawings and other submittals on hardware, software, and equipment to be installed or furnished. Begin no work until submittals have been reviewed for conformity with design intent. Provide drawings as AutoCAD 2004 (or

newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and 3 prints of each drawing on 11" x 17" paper. When manufacturer's cut sheets apply to a product series rather than a specific product, clearly indicate applicable data by highlighting or by other means. Clearly reference covered specification and drawing on each submittal. General catalogs shall not be accepted as cut sheets to fulfill submittal requirements. Select and show submittal quantities appropriate to scope of work.

2. Submittal approval does not relieve Contractor of responsibility to supply sufficient quantities to complete work. Provide submittals within 2 weeks of contract award on the following:

3. Direct Digital Control System Hardware - Distributed

.1 Complete bill of materials indicating quantity, manufacturer, model number, and relevant technical data of equipment to be used.

.2 Manufacturer's description and technical data such as performance curves, product specifications, and installation and maintenance instructions for items listed below and for relevant items not listed below:

- Direct digital controllers (controller panels)
- Transducers and transmitters
- Sensors (include accuracy data)
- Actuators
- Valves
- Relays
- Electrical and electro-pneumatic switches
- Control panels
- Power supplies
- Batteries
- Operator interface equipment
- Wiring
- Wiring diagrams and layouts for each control panel. Show termination numbers.
- Floor plan schematic diagrams indicating field sensor and controller locations.
- Riser diagrams showing control network layout, communication protocol, and wire types.

4. Central System Hardware and Software

.1 Provide new web server, software, and local workstation:.

.2 Controlled Systems

- Riser diagrams showing control network layout, communication protocol, and wire types.
- Schematic diagram of each controlled system. Label control points with point names. Graphically show locations of control elements.
- Schematic wiring diagram of each controlled system. Label control elements and terminals. Where a control element is also shown on control system

schematic, use the same name.
- Instrumentation list (Bill of Materials) for each controlled system. List each control system element in a table. Show element name, type of device, manufacturer, model number, and product data sheet number.
- Complete description of control system operation including sequences of operation. Include and reference schematic diagram of controlled system. List I/O points and software points specified. Indicate alarmed and trended points.
- Description of process, report formats, and checklists to be used in Control System Demonstration and Acceptance.
- BACnet Protocol Implementation Conformance Statement (PICS) for each submitted type of controller and operator interface.

5. Schedules

.1 Schedule of work provided within one month of contract award, indicating:

- Intended sequence of work items
- Start date of each work item
- Duration of each work item
- Planned delivery dates for ordered material and equipment and expected lead times
- Milestones indicating possible restraints on work by other trades or situations
- Monthly written status reports indicating work completed and revisions to expected delivery dates. Include updated schedule of work.

1.8 AS-BUILT DOCUMENTATION

1. Project Record Documents. Submit three copies of record (as-built) documents upon completion of installation for approval prior to final completion. Submittal shall consist of:

.1 Project Record Drawings. As-built versions of submittal shop drawings provided as AutoCAD 2004 (or newer) compatible files on magnetic or optical disk (file format: .DWG, .DXF, .VSD, or comparable) and 6 prints of each drawing on 11" x 17" paper.

.2 Testing and Commissioning Reports and Checklists. Completed versions of reports, checklists, and trend logs used to meet requirements of Control System Demonstration and Acceptance.

.3 Operation and Maintenance (O&M) Manual. Printed, electronic, or online help documentation of the following:

- As-built versions of submittal product data.
- Names, addresses, and telephone numbers of installing contractors and service representatives for equipment and control systems.
- Operator's manual with procedures for operating control systems: logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing setpoints and variables.
- Programming manual or set of manuals with description of programming

language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.

- Engineering installation, and maintenance manual or set of manuals that explains how to design and install new points, panels, and other hardware; how to perform preventive maintenance and calibration; how to debug hardware problems; and how to repair or replace hardware.
- Documentation of programs created using custom programming language including setpoints, tuning parameters, and object database. Electronic copies of programs shall meet this requirement if control logic, setpoints, tuning parameters, and objects can be viewed using furnished programming tools.
- Graphic files, programs, and database on magnetic or optical media.
- List of recommended spare parts with part numbers and suppliers.
- Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
- Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation or web server software, and graphics software.
- Licenses, guarantees, and warranty documents for equipment and systems.
- Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.

.4 Training Materials: Provide course outline and materials for each class at least two weeks before first class. Training shall be furnished via instructor-led sessions, computer-based training, or web-based training. Consultant will modify course outlines and materials if necessary to meet Owner's needs. Consultant will review and approve course outlines and materials at least three weeks before first class.

1.9 WARRANTY

1. Warrant work as follows:

.1 Warrant labor and materials for specified control system free from defects for a period of 24 months after final acceptance. Control system failures during warranty period shall be adjusted, repaired, or replaced at no additional cost or reduction in service to the Board. Respond during normal business hours within 24 hours of Board's warranty service request.

.2 Work shall have a single warranty date, even if Board receives beneficial use due to early system start-up. If specified work is split into multiple contracts or a multi-phase contract, each contract or phase shall have a separate warranty start date and period.

.3 If Consultant determines that equipment and systems operate satisfactorily at the end of final start-up, testing, and commissioning phase, Consultant will certify in writing that control system operation has been tested and accepted in accordance with the terms of this specification. Date of acceptance shall begin warranty period.

.4 Provide updates to operator workstation or web server software, project-specific software, graphic software, database software, and firmware that resolve Contractor-identified software deficiencies at no charge during warranty period. If available, Owner can purchase in-warranty service agreement to receive upgrades for functional enhancements associated with above-mentioned items. Do not install updates or upgrades without Owner's written authorization.

1.10 OWNERSHIP OF PROPRIETARY MATERIAL

1. Project-specific software and documentation shall become Owner's property. This includes, but is not limited to:

   .1 Graphics
   .2 Record drawings
   .3 Database
   .4 Application programming code
   .5 Documentation

PART 2 - PRODUCTS

2.1 MATERIALS

1. Use new products the manufacturer is currently manufacturing and selling for use in new installations. Do not use this installation as a product test site unless explicitly approved in writing by the Board. Spare parts shall be available for at least five years after completion of this contract.

2.2 COMMUNICATION

1. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135-2004, BACnet.

2. Install new wiring and network devices as required to provide a complete and workable control network. Use existing Ethernet backbone for network segments marked "existing" on project drawings

3. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

4. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

5. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

6. Inputs, outputs, and control variables used to integrate control strategies across multiple

controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified herein and shown on the drawings. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

7. Controllers with real-time clocks shall use the LAN Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated controller via the internetwork. If applicable, system shall automatically adjust for daylight saving and standard time.

8. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.3 OPERATOR INTERFACE

1. Board Central Server

   .1 New site databases and graphics files shall be installed on the designated central Board central server located in Mississauga, Ontario.

   .2 Provide written notification to the Board representative prior to installing new site databases to the Board server. Do not install software or make any changes to the server without the written consent of the Board representative.

   .3 Set up and configure the server software and area routers (where required) to allow for seamless access to the site BAS via the Board WAN.

   .4 Coordinate all activities related to the central server with the Board representatives. Provide the Board with detailed documentation related to any changes made to the server software, settings or protocols..

2. Local Service Ports

   .1 Every DDC panel shall be provided with a local network access port to connect to laptop computer. A user connected to the local access port shall have the same level of system access and functionality as being connected to the site workstation PC.

   .2 Where BAS points (4 or more) are located in a mechanical room that does not have a local BAS panel installed, a remote network access port shall be provided. The access port shall be installed in a hinged metal enclosure with key-lock set and lamicoid ID label.

3. Operator Interface.

   .1 Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.

4. Communication.

.1 Web server or workstation and controllers shall communicate using LonWorks protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and Lon/IP addressing.

2.4 SYSTEM SOFTWARE.

1. Operating System. Web server shall have an industry-standard professional-grade operating system. Acceptable systems include Microsoft Vista, Microsoft Windows XP Pro, Red Hat Linux, or Sun Solaris.

2. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot water system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using dynamic colors to represent zone temperature relative to zone setpoint.

3. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

4. Animation. Graphics shall be able to animate by displaying different image files for changed object status.

5. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.

6. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash).

7. System Tools. System shall provide the following functionality to authorized operators as an integral part of the operator interface or as stand-alone software programs. If furnished as part of the interface, the tool shall be available from each workstation or web browser interface. If furnished as a stand-alone program, software shall be installable on standard IBM-compatible PCs with no limit on the number of copies that can be installed under the system license.

8. Automatic System Database Configuration. Each workstation or web server shall store on its hard disk a copy of the current system database, including controller firmware and software. Stored database shall be automatically updated with each system configuration or controller firmware or software change.

9. Controller Memory Download. Operators shall be able to download memory from the system database to each controller.

10. System Configuration. Operators shall be able to configure the system.

11. Online Help. Context-sensitive online help for each tool shall assist operators in operating and editing the system.

12. Security. System shall require a user name and password to view, edit, add, or delete data.

13. Operator Access. Each user name and password combination shall define accessible viewing, editing, adding, and deleting functions in each system application, editor, and object.

14. Automatic Log Out. Automatically log out each operator if no keyboard or mouse activity is detected. Operators shall be able to adjust automatic log out delay.

15. Encrypted Security Data. Store system security data including operator passwords in an encrypted format. System shall not display operator passwords.

16. System Diagnostics. System shall automatically monitor controller and I/O point operation. System shall annunciate controller failure and I/O point locking (manual overriding to a fixed value).

17. Alarm Processing. System input and status objects shall be configurable to alarm on departing from and on returning to normal state. Operator shall be able to enable or disable each alarm and to configure alarm limits, alarm limit differentials, alarm states, and alarm reactions for each system object. Configure and enable alarm points as specified herein and indicated in the sequences of operation shown on the drawings. Alarms shall be BACnet alarm objects and shall use BACnet alarm services.

18. Alarm Messages. Alarm messages shall use an English language descriptor without acronyms or mnemonics to describe alarm source, location, and nature.

19. Alarm Reactions. Operator shall be able to configure (by object) actions workstation or web server shall initiate on receipt of each alarm. As a minimum, workstation or web server shall be able to log, print, start programs, display messages, send e-mail, send page, and audibly annunciate.

20. Alarm Maintenance. Operators shall be able to view system alarms and changes of state chronologically, to acknowledge and delete alarms, and to archive closed alarms to the workstation or web server hard disk from each workstation or web browser interface.

21. Trend Configuration. Operator shall be able to configure trend sample or change of value (COV) interval, start time, and stop time for each system data object and shall be able to retrieve data for use in spreadsheets and standard database programs. Controller shall sample and store trend data and shall be able to archive data to the hard disk.. Trends shall be BACnet trend objects.

22. Object and Property Status and Control. Operator shall be able to view, and to edit if applicable, the status of each system object and property by menu, on graphics, or through custom programs.

23. Reports and Logs. Operator shall be able to select, to modify, to create, and to print reports and logs. Operator shall be able to store report data in a format accessible by standard spreadsheet and word processing programs.

24. Standard Reports. Furnish the following standard system reports:

    .1 Objects. System objects and current values filtered by object type, by status (in alarm, locked, normal), by equipment, by geographic location, or by combination of filter criteria.

    .2 Alarm Summary. Current alarms and closed alarms. System shall retain closed alarms for an adjustable period.

    .3 Logs. System shall log the following to a database or text file and shall retain data for an adjustable period:

    .4 Alarm History.

    .5 Trend Data. Operator shall be able to select trends to be logged.

25. Operator Activity. At a minimum, system shall log operator log in and log out, control parameter changes, schedule changes, and alarm acknowledgment and deletion. System shall date and time stamp logged activity.

26. Graphics Generation. Graphically based tools and documentation shall allow Operator to edit system graphics, to create graphics, and to integrate graphics into the system. Operator shall be able to add analog and Digital values, dynamic text, static text, and animation files to a background graphic using a mouse.

27. Graphics Library. Complete library of standard HVAC equipment graphics shall include equipment such as chillers, boilers, air handlers, terminals, fan coils, and unit ventilators. Library shall include standard symbols for other equipment including fans, pumps, coils, valves, piping, dampers, and ductwork. Library graphic file format shall be compatible with graphics generation tools.

28. Custom Application Programming. Operator shall be able to create, edit, debug, and download custom programs. System shall be fully operable while custom programs are edited, compiled, and downloaded. Programming language shall have the following features:

    .1 Language. Language shall be graphically based or English language oriented. If graphically based, language shall use function blocks arranged in a logic diagram that clearly shows control logic flow. Function blocks shall directly provide functions listed below, and operators shall be able to create custom or compound function blocks. If English language oriented, language shall be based on the syntax of

BASIC, FORTRAN, C, or PASCAL, and shall allow for free-form programming that is not column-oriented or "fill-in-the-blanks."

.2 Programming Environment. Tool shall provide a full-screen, cursor-and-mouse-driven programming environment that incorporates word processing features such as cut and paste. Operators shall be able to insert, add, modify, and delete custom programming code, and to copy blocks of code to a file library for reuse in other control programs.

.3 Independent Program Modules. Operator shall be able to develop independently executing program modules that can disable, enable and exchange data with other program modules.

.4 Debugging and Simulation. Operator shall be able to step through the program observing intermediate values and results. Operator shall be able to adjust input variables to simulate actual operating conditions. Operator shall be able to adjust each step's time increment to observe operation of delays, integrators, and other time-sensitive control logic. Debugger shall provide error messages for syntax and for execution errors.

.5 Conditional Statements. Operator shall be able to program conditional logic using compound Boolean (AND, OR, and NOT) and relational (EQUAL, LESS THAN, GREATER THAN, NOT EQUAL) comparisons.

.6 Mathematical Functions. Language shall support floating-point addition, subtraction, multiplication, division, and square root operations, as well as absolute value calculation and programmatic selection of minimum and maximum values from a list of values.

.7 Variables: Operator shall be able to use variable values in program conditional statements and mathematical functions.

.8 Time Variables. Operator shall be able to use predefined variables to represent time of day, day of the week, month of the year, and date. Other predefined variables or simple control logic shall provide elapsed time in seconds, minutes, hours, and days. Operator shall be able to start, stop, and reset elapsed time variables using the program language.

.9 System Variables. Operator shall be able to use predefined variables to represent status and results of Controller Software and shall be able to enable, disable, and change setpoints of Controller Software as described in Controller Software section.

29. Portable Operator's Terminal. Provide all necessary software to configure an IBM-compatible laptop computer for use as a Portable Operator's Terminal. Operator shall be able to connect configured Terminal to the system network or directly to each controller for programming, setting up, and troubleshooting.

30. BACnet. Web server or workstation shall have demonstrated interoperability during at least one BMA Interoperability Workshop and shall substantially conform to BACnet Operator Workstation (B-OWS) device profile as specified in

ASHRAE/ANSI 135-2001, BACnet Annex L.

2.5 CONTROLLER SOFTWARE

1. Building and energy management application software shall reside and operate in system controllers. Applications shall be editable through operator workstation or web browser interface.

2. Scheduling. System shall provide the following schedule options as a minimum:

   .1 Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 5 occupied periods (5 start-stop pairs or 10 events).

   .2 Exception. Operator shall be able to designate an exception schedule for each of the next 365 days. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week.

   .3 Holiday. Operator shall be able to define 24 special or holiday schedules of varying length on a scheduling calendar that repeats each year.

3. System Coordination. Operator shall be able to group related equipment based on function and location and to use these groups for scheduling and other applications.

4. Remote Communication. System shall automatically contact operator workstation or server on receipt of critical alarms. If no network connection is available, system shall use a modem connection.

5. PID Control. System shall provide direct- and reverse-acting PID (proportional-integral-derivative) algorithms. Each algorithm shall have anti-windup and selectable controlled variable, setpoint, and PID gains. Each algorithm shall calculate a time-varying analog value that can be used to position an output or to stage a series of outputs.

6. Staggered Start. System shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts.

2.6 CONTROLLERS

1. General. Provide Building Controllers (BC), Advanced Application Controllers (AAC), Application Specific Controllers (ASC), Smart Actuators (SA), and Smart Sensors (SS) as required to achieve performance specified herein and indicated on the drawings. Every device in the system which executes control logic and directly controls HVAC equipment must conform to a standard LonWorks Device

2.7 COMMUNICATION.

1. Service Port. Each controller shall provide a service communication port for connection to a Portable Operator's Terminal. Connection shall be extended to space temperature sensor ports where shown on drawings.

.1 Signal Management. BC and ASC operating systems shall manage input and output communication signals to allow distributed controllers to share real and virtual object information and to allow for central monitoring and alarms.

.2 Data Sharing. Each BC and AAC shall share data as required with each networked BC and AAC.

.3 Environment. Controller hardware shall be suitable for anticipated ambient conditions.

.4 Controllers used outdoors or in wet ambient conditions shall be mounted in waterproof enclosures and shall be rated for operation at -29°C to 60°C (-20°F to 140°F).

.5 Controllers used in conditioned space shall be mounted in dust-protective enclosures and shall be rated for operation at 0°C to 50°C (32°F to 120°F).

.6 Real-Time Clock. Controllers that perform scheduling shall have a real-time clock.

2.8 SERVICEABILITY.

1. Controllers shall have diagnostic LEDs for power, communication, and processor.

2. Wires shall be connected to a field-removable modular terminal strip or to a termination card connected by a ribbon cable.

3. Each BC and AAC shall continually check its processor and memory circuit status and shall generate an alarm on abnormal operation. System shall continuously check controller network and generate alarm for each controller that fails to respond.

2.9 MEMORY.

1. Controller memory shall support operating system, database, and programming requirements.

2. Each BC and AAC shall retain BIOS and application programming for at least 72 hours in the event of power loss.

3. Each ASC and SA shall use nonvolatile memory and shall retain BIOS and application programming in the event of power loss. System shall automatically download dynamic control parameters following power loss.

4. Each controller shall have a min. 25% spare memory to allow for future expansion.

5. Immunity to Power and Noise. Controllers shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shutdown below 80% nominal voltage. Operation shall be protected against electrical noise of 5 to 120 Hz and from keyed radios up to 5 W at 1 m (3 ft).

6. Transformer. ASC power supply shall be fused or current limiting and shall be rated at a minimum of 125% of ASC power consumption.

2.10 INPUT AND OUTPUT INTERFACE

1. General. Hard-wire input and output points to BCs, AACs, ASCs, or SAs.

2. Protection. Shorting an input or output point to itself, to another point, or to ground shall cause no controller damage. Input or output point contact with up to 24 V for any duration shall cause no controller damage.

3. Digital Inputs. Digital inputs shall monitor the on and off signal from a remote device. Digital inputs shall provide a wetting current of at least 12 mA and shall be protected against contact bounce and noise. Digital inputs shall sense dry contact closure without application of power external to the controller.

4. Pulse Accumulation Inputs. Pulse accumulation inputs shall conform to Digital input requirements and shall accumulate up to 10 pulses per second.

5. Analog Inputs. Analog inputs shall monitor low-voltage (0-10 Vdc), current (4-20 mA), or resistance (thermistor or RTD) signals. Analog inputs shall be compatible with and field configurable to commonly available sensing devices.

6. Digital Outputs. Digital outputs shall send an on-or-off signal for on and off control. Building Controller Digital outputs shall have three-position (on-off-auto) override switches and status lights. Outputs shall be selectable for normally open or normally closed operation.

7. Analog Outputs. Analog outputs shall send a modulating 0-10 Vdc or 4-20 mA signal as required to properly control output devices. Each Building Controller analog output shall have a two-position (auto-manual) switch, a manually adjustable potentiometer, and status lights. Analog outputs shall not drift more than 0.4% of range annually.

8. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated Digital outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as VAV terminal units, duct-mounted heating coils, and zone dampers.

9. Universal Inputs and Outputs. Inputs and outputs that can be designated as either Digital or analog in software shall conform to the provisions of this section that are appropriate for their designated use.

2.11 POWER SUPPLIES AND LINE FILTERING

1. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.

2. DC power supply output shall match output current and voltage requirements. Unit shall

be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

3. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MILSTD 810C for shock and vibration.

4. Line voltage units shall be UL recognized and CSA listed.

2.12 POWER LINE FILTERING.

1. Provide internal or external transient voltage and surge suppression for workstations and controllers. Surge protection shall have:

   .1 Dielectric strength of 1000 V minimum
   .2 Response time of 10 nanoseconds or less
   .3 Transverse mode noise attenuation of 65 dB or greater
   .4 Common mode noise attenuation of 150 dB or greater at 40-100 Hz

2.13 CONTROL DEVICES AND SENSORS

1. Automatic Control Dampers

   .1 The automatic control dampers not provided as part of the packaged equipment shall be supplied by the Control Subcontractor and install by the Mechanical Contractor.

   .2 The automatic control dampers shall be opposed blade type for mixing and parallel blade type for “on-off” service.

   .3 Outdoor air and exhaust air dampers shall be ultra-low leakage models, with insulated blades and frames. The return air dampers do not have to include insulated blades or frames.

   .4 Maximum damper blade length shall be 4’-0”(1.2m). Maximum permissible leakage shall not exceed 1% of the total flow based on an approach velocity of 1,500fpm(7.5m/s) over a temperature range of –30 °F (–34.4 °C) to 100 °F (37.7°C) and a pressure of 3 in H20 (0.75 kpa). Unless otherwise noted, blades are to be constructed of formed galvanized steel with neoprene seal edges, continuous stops and seals on all sides, oil impregnated bronze bearings and galvanized steel channel frames.

   .5 Centre bar linkage connectors shall be used wherever possible but where centre bar linkage cannot be used due to space limitations, external linkage connectors may be used.

   .6 Standard of Acceptance: TAMCO 9000 series (insulated) or 1500 series (non-insulated),

2. Automatic Control Damper Actuators

.1 All new actuators for control dampers shall be electric type and be powered by a single phase AC 24V overload-proof synchronous motor.

.2 All newly provided actuators shall be direct-coupled type for both modulating or two position control dampers.

.3 Damper actuators shall accept a 0-10VDC control voltage signal for all proportional applications

.4 All damper actuators shall be selected to operate maximum damper loads of 28 sq.ft. (2.6 sq.m.)

.5 Each actuator shall be “fail safe”, complete with external adjustable stops to limit the length of stroke in either direction and mounted on an adjustable bracket. Operating arms shall have double yoke linkages and double set of screws for fastening to the damper shaft.

.6 The standard of acceptance shall be Belimo.

3. Control Valves

.1 Provide valves for the operating pressure and temperature conditions of the system. Ensure that valves will close against system operating differential pressures.

.2 Provide globe body control valves with characteristics to suit the application. Straight through (two-port) water valves shall be single seated with equal percentage flow characteristics. Three-port valves shall be linear for each port to give constant total flow.

.3 Valves shall have stainless steel stems and packing to suit the application.

.4 Valves 50mm (2") and smaller shall have screwed 1035 kPa (150 lb.) bronze bodies.

.5 Valves 65mm (2½") and larger shall have flanged 860 kPa (125 lb.) cast iron bodies.

.6 Use positive positioning relays on valves that are sequenced with other actuators or where necessary for high shut-off rating.

.7 Unless specifically mentioned otherwise, the design flow pressure drop shall be as follows:

- Hot water valves 20 kPa (3 psi)
- Glycol valves 20 kPa (3 psi)
- Valves for terminal unit application (radiation and coils) 7 kPa (1 psi)

.8 Acceptable Manufacturer: Belimo

4. Valve Actuators

.1 Control valves shall be provided with electric or electronic actuators (as specified in sequences of operation). Select actuators to allow the control valve to shut off against normal inlet operating pressures.

.2 Electric valve actuators are of the enclosed reversible gear drive type with spring return to fail safe position. Valve actuators for terminal unit applications (radiation and reheat coils) should fail “OPEN”. Wax type actuators are not acceptable.

.3 Electric valve actuators accept modulating control signals as required. Actuators have no balance relays or mechanical travel limiting switches. Provide actuators with potentiometer adjustment of zero signal position and angular rotation. Conceal all adjustments with access by means of removable cover plate. Provide actuators with feedback signal 2-10 VDC.

.4 Acceptable Manufacturer: Belimo

5. Duct Humidity Sensors

.1 Provide humidity sensors with the following minimum characteristics:

- Operating range from 10% - 90%RH over 0-60 °C temperature range.
- End-to-end accuracy of +/- 2% of operating range, with maximum temperature dependence of 0.2% per °C change.
- 200mm long probe, with enclosure for mounting in duct.
- 4-20mA output only. Voltage output is not acceptable

.2 Standard of Acceptance:. Enercorp HTM-D-420-2

6. Duct Temperature Sensors

.1 Provide duct mounted temperature sensors (DTS) with the following minimum characteristics:

- Sensor encapsulated in a 200mm long, 6mm OD copper or stainless steel probe.
- Operating range 0-60 degrees C.
- End-to-end accuracy +/- 0.3 °C.

.2 Assembly complete with wiring housing and mounting flange.

.3 Standard of Acceptance:. Enercorp TS-D-12-T-10K

7. Duct Averaging Temperature Sensors

.1 Provide plenum mounted mixed air temperature averaging type sensors with the following minimum characteristics:

- Constructed of FT6 plenum rated cable incorporating a minimum of 9 temperature sensors encapsulated at equal distances along the 24 foot length of the element. The assembly acts as a single sensor reporting the average temperature from all individual sensors.
- End-to-end accuracy +/- 0.3 °C.

.2 Mount in a zigzag manner to provide continuous coverage of the entire duct cross-sectional area.

.3 The use of thermistor type sensors is acceptable.

.4 Standard of Acceptance:. Enercorp TS-FC-24-9-T-RTD

8. CO_2 Sensors

.1 Provide CO_2 sensors for either wall or duct mounting applications as specified. Provide a heavy duty metal guard to protect the sensor when mounted on walls. Provide the factory-supplied duct mounting kit for all duct mount applications.

.2 The sensor shall be microprocessor controlled, fully digital, non-dispersive dual wavelength infrared technology with temperature compensation. The device output shall be 4 to 20mA.

.3 The sensor shall have a measurement range of 0 to 3000ppm with an accuracy of +/-25ppm in the 15-30C range. Long term stability shall be no greater than 20 ppm per year. The user selectable range shall be 0 to 1500ppm.

.4 Install the sensor in accordance with all manufacturer's instructions. Wall mounted sensors shall be installed at a minimum height of 72" above the finished floor. Sensors shall not be mounted on an outside wall, close to a window, door or in draft areas with direct airflow.

.5 The standard of acceptance shall be Comag SmartScan PPM 4022H available from Comag IR Technology Inc. (204-444-7000)

9. Outdoor Air Sensors

.1 Provide outdoor air temperature sensors with the following minimum characteristics:

- Each sensor shall be a 6", 10K thermistor probe
- Minimum two sensors shall be installed for each site.
- Both sensors shall be mounted inside a heavy-duty (blow-proof) solar shield.

.2 Provide a heavy-duty, metal, wire guard.

.3 Standard of Acceptance: Enercorp

10. Current Transmitters.

.1 AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

.2 Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.

.3 Unit shall be split-core type for clamp-on installation on existing wiring.

11. Current Transformers.

.1 AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material.

.2 Transformers shall be available in various current ratios and shall be selected for ±1% accuracy at 5 A full-scale output.

.3 Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

12. Voltage Transmitters.

.1 AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment.

.2 Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be ±1% full-scale at 500 ohm maximum burden.

.3 Transmitters shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized at 600 Vac rating.

13. Voltage Transformers.

.1 AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection.

.2 Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide ±0.5% accuracy at 24 Vac and 5 VA load.

.3 Windings (except for terminals) shall be completely enclosed with metal or plastic.

14. Current Switches.

.1 Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements.

15. Current Sensors (Analog)

.1 Current sensors (CT) shall be used for status monitoring of all motor-driven equipment, where specified.

.2 Technical Performance – Output should be only 4-20mA only. Voltage output will not be accepted. End-to-end accuracy +/- 1% of full scale at each range.

.3 The current sensors shall be mounted inside the starter cabinets whenever possible. If this is not possible due to space limitation, provide an enclosure to house the sensor.

.4 Standard of Acceptance: Enercorp

16. Status Relays (Solid State)

.1 The status relays shall be mounted inside newly provided enclosures mounted near the respective equipment starter cabinets.

.2 Standard of Acceptance: Omron

17. Firestopping and Smoke Seal Materials

.1 Asbestos-free elastomeric materials tested, listed and labelled by ULC in accordance with CAN4-S115-M85, for installation in U.L.C. designated firestopping and smoke seal Systems. These Systems shall provide a positive fire, water and smoke seal and a fire- resistance rating (flame, smoke hose stream and temperature) not less than the fire resistance rating of surrounding construction.

.2 Materials shall form ULC listed or UL classified assemblies and be compatible with abutting dissimilar materials and finishes.

.3 Standard of Acceptance:

- 3M Canada Limited
- A/D Fire Protection System Ltd.
- Fire Stop System

18. Wall Opening Covering Plates

.1 All hole covering plates used on this project shall be stainless steel 18-8 chrome metal alloy, type 302, non-magnetic type for finished areas and pressed steel for unfinished areas. Finish brush marks shall be run in a vertical direction.

19. Access Doors

.1 Access doors installed in unfinished areas shall be constructed of 12 ga prime coated steel and of stainless steel for all areas finished with tile or marble surfaces.

.2 Access doors shall be complete with 180? opening door, round safety corners,

concealed hinges, screwdriver latches, plaster lock and anchor straps.

.3 Access doors shall be 24'x 24' or 12'x 18' as per site condition.

.4 Access doors in fire rated construction shall be ULC listed and labeled and of a rating to maintain the fire separation integrity.

.5 Standard of Acceptance:

- Zurn Industries Canada Limited
- LeHage Industries Limited
- Acudor Acorn Limited.

2.14 LOCAL CONTROL PANELS.

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.

2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.

3. Each local panel shall have a control power source power switch (on-off) with overcurrent protection.

2.15 FAIL STATE POSITION OF OUTPUTS

1. Unless specified otherwise, configure BAS output points for the following fail state (e.g. device position upon panel failure):

.1 Supply/Return Fans:	ON
.2 Mechanical cooling:	OFF
.3 Fresh Air Dampers:	Closed
.4 Exhaust air dampers:	Closed
.5 Return Air dampers:	Open
.6 Humidifiers:	OFF

2.16 LAN CABLING

1. All LAN cabling shall be Category V as defined by EIA/TIA 568A. The contractor shall test all cabling to verify that 100Mb bandwidth is supported. See commissioning requirements.

2. Cabling shall be 4 pair, 100 ohm UTP, #24 AWG solid copper conductor PVC insulated, with blue or grey colour coded jacket. FT6 rated cable shall be used unless otherwise required to meet building codes or by-laws.

3. Data outlets shall be RJ45, 8 pin connectors, with 50 microns of hard gold over nickel,

minimum durability of 750 mating cycles and contact pressure of 100 grams per contact. Transmission characteristics shall meet TSB-40 Category V.

4. Provide one RJ45 data outlet adjacent to each device to be terminated (e.g. workstation PC, DDC panel, hub, etc.) Use a flexible patch cable to connect from the data outlet to the end device. For Delta Controls installations, provide a duplex data outlet at the workstation PC to accommodate the remote security key wiring. LAN cabling shall not be directly terminated to any device.

5. Provide protection from EMI sources in accordance with CSA-T530 article 4

6. The contractor shall test all cabling to verify conformance with TIA /EIA TSB-67 - Basic Link Test using a Level 2, bi-directional tester. See commissioning requirements.

7. Where there are more than 2-90 degree in a conduit run, provide a pull box between sections so that there are two bends or less in any one section.

8. Where a conduit run requires a reverse bend, between 100 degrees and 180 degrees, insert a pull box at each bend having an angle from 100 degrees to 180 degrees.

9. Ream all conduit ends and install insulated bushings on each end.

10. Terminate all conduits that protrude through the structural floor 2” above the concrete base.

11. Do not use a pull box in lieu of a conduit bend. Align conduits that enter a pull box from opposite ends with each other.

2.17 FIBER OPTIC CABLE SYSTEM

1. Optical Cable. Optical cables shall be duplex 900 mm tight-buffer construction designed for intra-building environments. Sheath shall be UL listed OFNP in accordance with NEC Article 770. Optical fiber shall meet the requirements of FDDI, ANSI X3T9.5 PMD for 62.5/125mm.

2. Connectors. Field terminate optical fibers with ST type connectors. Connectors shall have ceramic ferrules and metal bayonet latching bodies.

PART 3 - EXECUTION

3.1 EXAMINATION

1. Thoroughly examine project plans for control device and equipment locations. Report discrepancies, conflicts, or omissions to Consultant for resolution before starting rough-in work.

2. Inspect site to verify that equipment can be installed as shown. Report discrepancies, conflicts, or omissions to Consultant for resolution before starting rough-in work.

3. Remove all existing field and panel mounted control devices (e.g. transducers,

controllers, thermostats, etc.) that have been made redundant or inoperative by the new BAS equipment and control strategies. Remove any other controls as specified or directed by the Consultant

4. The control sequences indicate only the principal items of equipment controlling the systems. Supplement each control system with relays and auxiliaries to enable each system to perform as specified and to permit proper operation and supervision of it.

5. Provide complete identification and labeling for new and existing devices and equipment.

6. Provide new cabling, conduits, control cabinets, power supplies and other auxiliary equipment, as required for a complete operational system.

7. The layout drawings do not show all controlled devices and operators and are intended to indicate the general location of equipment to be controlled; for full extent of instrumentation refer to the controls diagrams and sequences of operation.

3.2 CUTTING AND PATCHING

1. All cutting, patching, painting and making good for the installation of the BAS work shall be done by the BAS Contractor. All cutting shall be performed in a neat and true fashion, with proper tools and equipment to the Consultant's and/or Owner's approval. The surfaces shall be made good to reasonably match existing finishes

2. Location of the existing services concealed in the construction, if any, shall be determined prior to drilling or cutting an opening. If required, the Contractor is to x-ray the walls or slabs and in any case he shall not drill or cut any surface without the Owner's representatives approval.

3. The Contractor shall be responsible for the repair of any damage to existing services, exposed or concealed, caused as a result of this Work.

3.3 PROTECTION

1. Controls Contractor shall protect against and be liable for damage to work and to material caused by Contractor's work or employees.

2. Controls Contractor shall be responsible for work and equipment until inspected, tested, and accepted. Protect material not immediately installed. Close open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

3.4 GENERAL WORKMANSHIP

1. Install equipment, piping, and wiring or raceway horizontally, vertically, and parallel to walls wherever possible.

2. Provide sufficient slack and flexible connections to allow for piping and equipment vibration isolation.

3. Install equipment in readily accessible locations as defined by National Electrical Code (NEC) Chapter 1 Article 100 Part A.

4. Verify wiring integrity to ensure continuity and freedom from shorts and ground faults.

5. Equipment, installation, and wiring shall comply with industry specifications and standards and local codes for performance, reliability, and compatibility.

3.5 FIELD QUALITY CONTROL

1. Work, materials, and equipment shall comply with rules and regulations of applicable local, state, and federal codes and ordinances as identified in this section.

2. Continually monitor field installation for code compliance and workmanship quality.

3. Contractor shall arrange for work inspection by local or provincial authorities having jurisdiction over the work.

3.6 EXISTING EQUIPMENT

1. Wiring. Interconnecting control wiring shall be removed and shall become Contractor's property unless specifically noted or shown to be reused.

2. Local Control Panels. Remove and deliver existing control panels to Owner.

3. Repair. Unless otherwise directed, Contractor is not responsible for repair or replacement of existing energy equipment and systems, valves, dampers, or actuators. Notify Consultant in writing immediately of existing equipment that requires maintenance.

4. Indicator Gauges. Ensure operation of and recalibrate for reasonable accuracy or replace existing gauges.

5. Electronic Sensors and Transmitters. Remove and deliver existing sensors and transmitters to Owner.

6. Controllers and Auxiliary Electronic Devices. Remove and deliver existing controllers and auxiliary electronic devices to Owner.

7. Existing System Operating Schedule. Existing mechanical system may be disabled during this work.

8. Patch holes and finish to match existing walls.

9. At Owner's request, items to be delivered to Owner shall instead be properly disposed of. Hazardous materials shall be disposed in accordance with current regulations and applicable by-laws.

3.7 WIRING

1. Control and interlock wiring and installation shall comply with national and local electrical codes, and manufacturer's recommendations.

2. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway as specified by NEC.

3. All wiring shall be installed in EMT conduit unless specified otherwise. Exposed wiring in finished areas (e.g. corridors, classrooms, gymnasiums, etc.) shall be installed in wiremold (colour to match surrounding area).

4. Wiring from DDC controllers to sensors and actuators and control system network and low voltage wiring running in accessible ceilings may be installed using LVT cable. Where the ceiling is used as a return air plenum, plenum rated cable shall be used in lieu of LVT cable.

5. Install EMT and cable at right angles to building lines, securely fastened, and in accordance with current electrical codes and standards.

6. Power and control wiring shall be copper conductor (RW90). For power wiring, provide #12 AWG (minimum) with a 3% maximum voltage drop in accordance with CEC requirements. Control wiring shall be a minimum of #14 AWG, unless otherwise specified.

7. The wires smaller than 18 gauge shall not be used and will not be accepted on the project except for: wiring between terminal computer devices, wire in standard communication cables, such as printers and short haul modems, wire used in communication networks, i.e. any cable transferring digital data, using twisted shielded pairs.

8. The wiring from panels to devices shall be installed without splices. The use of crimp connectors is not allowed when connecting field wiring to sensor or device leads. The use of wire nuts is acceptable in this application.

9. Power for control system shall not be obtained by tapping into miscellaneous circuits that could be inadvertently switched off. Only dedicated circuit(s) shall power the control system. Provide additional breakers or electrical panels as required.

10. Mount transformers and other peripheral equipment in panels located in serviceable areas. Provide line-side breakers/fuses for each transformer.

11. All 120 VAC power for any controls equipment shall be from dedicated circuits. Provide a breaker lock for each breaker used to supply the control system. Update the panel circuit directory.

12. A dedicated power circuit may be used to power DDC panels and equipment within the same or adjoining mechanical rooms. The use of one power circuit to power DDC panels distributed throughout the building is not acceptable.

13. The controller may be powered from the equipment that it is directly controlling (i.e.

heat pump, rooftop unit) only if the controller controls no other equipment and the power supply to the controller remains energized independently of unit operation or status.

14. Provide all required code gauge boxes, connectors and other wiring accessories.

15. For all DC wiring, positive conductors shall be WHITE or RED in colour while negative conductors shall be BLACK in colour.

3.8 COMMUNICATION WIRING

1. Communication wiring shall be low-voltage Class 2 wiring.

2. Install communication wiring in separate raceways and enclosures from other Class 2 wiring.

3. During installation do not exceed maximum cable pulling, tension, or bend radius specified by the cable manufacturer.

4. Verify entire network's integrity following cable installation using appropriate tests for each cable.

5. Install lightning arrestor according to manufacturer's recommendations between cable and ground where a cable enters or exits a building.

6. Each run of communication wiring shall be a continuous length without splices when that length is commercially available. Runs longer than commercially available lengths shall have as few splices as possible using commercially available lengths.

7. Label communication wiring to indicate origination and destination.

8. Ground coaxial cable according to NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

3.9 FIBER OPTIC CABLE

1. During installation do not exceed maximum pulling tensions specified by cable manufacturer. Post-installation residual cable tension shall be within cable manufacturer's specifications.

2. Install cabling and associated components according to manufacturers' instructions. Do not exceed minimum cable and unjacketed fiber bend radii specified by cable manufacturer.

3.10 INSTALLATION OF SENSORS

1. Install sensors according to manufacturer's recommendations.

2. Mount sensors rigidly and adequately for operating environment.

3. Air seal wires attached to sensors in their raceways or in the wall to prevent sensor readings from being affected by air transmitted from other areas.

3.11 IDENTIFICATION OF HARDWARE AND WIRING

1. Label wiring and cabling, including that within factory-fabricated panels, with control system address or termination number at each end within 5 cm (2 in.) of termination.

2. Label pneumatic tubing at each end within 5 cm (2 in.) of termination with a descriptive identifier.

3. Permanently label or code each point of field terminal strips to show instrument or item served.

4. Label control panels with minimum 1 cm (½ in.) letters on laminated plastic nameplates.

5. Label each control component with a permanent label. Label plug-in components such that label remains stationary during component replacement.

6. Label room sensors related to terminal boxes or valves with nameplates.

7. Manufacturers' nameplates and UL or CSA labels shall be visible and legible after equipment is installed.

8. Label identifiers shall match record documents.

3.12 PROGRAMMING

1. Point Naming. Name points as shown on the equipment points list provided with each sequence of operation. See sequences of operation on the drawings. If character limitations or space restrictions make it advisable to shorten the name, the abbreviations given in Appendix B may be used. Where multiple points with the same name reside in the same controller, each point name may be customized with its associated Program Object number. For example, "Zone Temp 1" for Zone 1, "Zone Temp 2" for Zone 2.

2. Software Programming. Programming shall provide actions for each possible situation. Graphic- or parameter-based programs shall be documented. Text-based programs shall be modular, structured, and commented to clearly describe each section of the program.

3. Application Programming. Provide application programming that adheres to sequences of operation specified and shown on the drawings. Program documentation or comment statements shall reflect language used in sequences of operation.

4. System Programming. Provide system programming necessary for system operation.

3.13 OPERATOR INTERFACE.

1. Standard Graphics. Provide graphics as specified herein. Show on each equipment

graphic input and output points and relevant calculated points such as indicated on the applicable Points List as indicated on the drawings. Point information on graphics shall dynamically update.

2. Install, initialize, start up, and troubleshoot operator interface software and functions (including operating system software, operator interface database, and third-party software installation and integration required for successful operator interface operation).

3.14 EQUIPMENT ENCLOSURES AND LOCATIONS

1. Provide new enclosures for all field equipment (e.g. DDC panels, transducers, relays, etc.). Enclosures shall be equipped with a hinged door and latch. Provide a OWNER-standard key/lock set for each enclosure.

2. Obtain written approval of the Consultant prior to re-using existing enclosures or cabinets. Provide a OWNER-standard lockset for all re-used enclosures or cabinets.

3. Mount all enclosures in serviceable areas of mechanical rooms, storage rooms or janitor closets. Obtain written approval of the Consultant prior to mounting any enclosure in ceiling spaces or more than 5'-6" above the finished floor.

4. All transformers and power supplies for control equipment shall be installed in new dedicated metal cabinets with hinged, lockable covers located in the proximity of their dedicated controller cabinets.

5. Include within a DDC panel enclosure one 120 VAC duplex receptacle for portable PC power, if the controller cabinet is located further than 5'-0" from the nearest wall receptacle.

6. Ensure that enclosures are sized to allow for ease of servicing of all equipment contained within. Enclosures containing DDC panels shall be sized to allow for the installation of the maximum allowable number of expansion panels/boards. Do not mount other equipment in a manner that may interfere with the future installation of expansion panels/boards.

7. For enclosures containing pneumatic transducers or devices, provide one pressure gauge (1-1/2" dial, 0-30psi) for the main air line supply.

3.15 IDENTIFICATION AND LABELING OF CONTROL EQUIPMENT

1. All panels must have a lamicoid tag (min. 3"x1") affixed to the front face indicating panel designation and function (i.e. "BAS Panel 1" or "Relay Panel 3").

2. All field sensors or devices must have a lamicoid tag (min. 3"x1") attached with tie-wrap or adhesive indicating the point software name and hardware address (i.e. AHU1_MAT, 2.IP4). Tags must be secured by screws where mounted outside of the building, in un-heated spaces, in high humidity areas or where subject to vibration.

3. Room sensors or other sensors in finished areas must have a lamicoid tag affixed to

the front cover. This tag shall be minimum 1"x ½" and indicate the point software name and hardware address.

4. All devices within a field enclosure shall be identified via a label or tag.

5. All BAS panel power sources must be identified by a label (min. 3"x1") indicating the source power panel designation and circuit number (i.e. "120vac fed from LP-2A cct #1).

6. All field control equipment panels fed from more than one power source must have a warning label on the front cover.

7. All wires shall be identified with the hardware address with a band-type self-adhesive strips or clip-on plastic wire markers at both ends.

8. All rotating equipment controlled by the BAS shall have a tag or label affixed indicating that the equipment may start without warning.

9. The location of the phone line manager shall be indicated via a label affixed to the inside cover of the modem enclosure or BAS panel.

10. All BAS panels will be supplied with a point's list sheet (within a plastic sleeve) attached to the inside door.

11. The points list shall identify the following for each point:

.1 Panel number.
.2 Panel location.
.3 Hardware address.
.4 Software name.
.5 Point description.
.6 Field device type.
.7 Point type (i.e. AI or DO).
.8 Device fail position.
.9 Device manufacturer.
.10 Model number or reference.
.11 Wire tag reference.

12. Provide laminated wiring diagrams for all field mounted relay enclosures. Securely attach to the inside door. Identify power panels and circuit numbers of the equipment being controlled.

13. Provide laminated wiring diagrams or modify existing equipment wiring diagrams wherever the BAS interfaces to other equipment. (e.g. boilers, chillers, etc.). Securely attach to the inside of the respective control cabinet.

14. Provide lamacoid labels indicating the required operating sequences, on the boilers and valves, where the boiler plants have manual or automatic isolating valves. Submit actual wording to the Consultant for approval prior to fabrication and installation.

15. Provide lamicoid or machine labels (as outlined above) for all interposing relays or contactors used in control circuits. The labels shall include the related point software name and hardware address

16. Provide a lamicoid label to identify the location of concealed devices above the ceiling space. Mount the label on the ceiling grid t-bar or a permanent surface adjacent to the devices. The label shall contain the wording “BAS Devices Above”.

17. Provide lamicoid labels for all auxiliary HVAC equipment (e.g. force flow cabinets, unit ventilators, unit heater, window AC units, etc.) controlled by the BAS. Mount the labels in the vicinity of the existing thermostat or power switch for the unit. The label shall contain the wording “Under BAS Control”.

18. Where directed by the Consultant, provide any and all additional labelling, diagrams. schematics or instructions as may be required to facilitate the correct operation and maintenance of controlled building systems.

3.16 SYSTEMS HARDWARE COMMISSIONING

1. This contractor shall be responsible for the “end to end” commissioning, testing, verification and start-up of the complete control system hardware including panels, sensors, transducers, end devices, relays and wiring. Where applicable, this shall include any points from an existing and/or re-used automation system in the building.

2. The contractor shall conduct the hardware commissioning at the facility.

3. When the site hardware installation is 100% completed (including all labeling and documentation), the contractor shall provide written notification to the Owner to schedule the hardware commissioning dates for each facility.

4. Owner reserves the right, at it’s sole discretion, to discontinue site commissioning at any time if any part of the site hardware installation is found to be incomplete on the date of commissioning. If this occurs, the Contractor shall assume responsibility for any additional costs related to rescheduling of the site commissioning.

5. The Contractor shall prepare a hardware commissioning report containing the following information and test results:

   .1 Analogue inputs (i.e. temperatures, pressure, etc.) shall be verified with an approved calibration device. All actual temperature readings should be with +/- 1C of the readings observed at the workstation. Record calibration adjustments and settings.

   .2 Analogue outputs shall be verified by manually commanding the output channel from the operator workstation to two or more positions within the 0-100% range and verifying the actual position of the actuator or device. All devices shall operate over their entire 0-100% range from a minimum control range of 10-90%. Record the actual output scale range (channel output voltage versus controller command) for

each analogue end device

.3 Digital outputs shall be verified by witnessing the actual start/stop operation of the equipment under control.

.4 Digital inputs shall be verified by witnessing the status of the input point as the equipment is manually cycled on and off.

.5 Record all out-of-season or unverified points in the commissioning report as “non-commissioned”.

.6 Identify any existing equipment (valves, dampers, fan starters, etc..) that are inoperative or require maintenance or repair.

6. The BAS field panel power source shall be toggled on and off to ensure reboot functionality and power down memory retention of all parameters. During the power down test, all controlled system outputs shall go to their fail-safe position.

7. Verify PID loop tuning parameters by applying a step change to the current setpoint and observing the response of the controlled device. Setpoint should be reached in an acceptable period of time without excessive cycling or hunting of the controlled device. Provide a graph of the trend response to setpoint change for important controlled devices (e.g. valves 1-inch or larger, dampers on major air handlers, etc.)

8. Provide confirmation that a series of test alarms has been successfully received at a designated remote monitoring workstations.

9. Include with the hardware commissioning report a site floor plan indicating the location of all equipment installed in concealed or recessed locations (e.g. interposing relays in ceiling spaces).

10. Provide testing of all LAN cabling to ensure that 100Mb bandwidth is supported.

11. Verify conformance with TIA /EIA TSB-67 - Basic Link Test using a Level 2, bi-directional tester. Provide all equipment necessary to carry out the required tests.

12. The hardware commissioning report must be signed and dated by the Contractor’s technician performing the tests and participating Owner representative.

13. At the completion of site commissioning, submit four (4) copies of hardware commissioning report to the Owner.

3.17 SUBSTANTIAL COMPLETION INSPECTION

1. At the completion of the site hardware inspection, the Contractor shall test and verify that the system programming, graphics and alarm software is operating correctly and is in compliance all requirements of the specifications.

2. The Contractor shall provide written notification to the Board that the site is ready for the Substantial Completion Inspection by the Consultant.

3. At the conclusion of the Substantial Completion Inspection, the Consultant shall issue a comprehensive site deficiency report to the Contractor for his immediate action.

4. The Contractor shall correct all items noted in the site deficiency report within ten (10) business days of receipt.

5. The Contractor shall provide written notification to the Owner that all items on the Consultant's site deficiency report have been corrected.

3.18 CONTROL SYSTEM DEMONSTRATION AND ACCEPTANCE

1. Demonstration. Prior to acceptance, perform the following performance tests to demonstrate system operation and compliance with specification after and in addition to tests specified above. Provide Consultant with log documenting completion of Substantial Completion Inspection.

2. Consultant will be present to observe and review system demonstration. Notify Consultant at least 10 days before system demonstration begins.

3. Demonstration shall follow process submitted and approved. Complete approved checklists and forms for each system as part of system demonstration.

4. Demonstrate actual field operation of each sequence of operation as specified herein. Provide at least two persons equipped with two-way communication. Demonstrate calibration and response of any input and output points requested by Consultant. Provide and operate test equipment required to prove proper system operation.

5. Demonstrate compliance with sequences of operation through each operational mode.

6. Demonstrate complete operation of operator interface.

7. Demonstrate each of the following.

   .1 DDC loop response. Supply graphical trend data output showing each DDC loop's response to a setpoint change representing an actuator position change of at least 25% of full range. Trend sampling rate shall be from 10 seconds to 3 minutes, depending on loop speed. Each sample's trend data shall show setpoint, actuator position, and controlled variable values. Consultant will require further tuning of each loop that displays unreasonably under- or over-damped control.

   .2 Building fire alarm system interface.

   .3 Trend logs for each system. Trend data shall indicate setpoints, operating points, valve positions, and other data as specified in the points list provided with each sequence of operation. Each log shall cover three 48-hour periods and shall have a sample frequency not less than 10 minutes or as specified on its points list. Logs shall be accessible through system's operator interface and shall be retrievable for

use in other software programs.

.4 Tests that fail to demonstrate proper system operation shall be repeated after Contractor makes necessary repairs or revisions to hardware or software to successfully complete each test.

3.19 ACCEPTANCE.

1. After tests described in this specification are performed to the satisfaction of both Consultant and Board, Consultant will accept control system as meeting completion requirements. Consultant may exempt tests from completion requirements that cannot be performed due to circumstances beyond Contractor's control. Consultant will provide written statement of each exempted test. Exempted tests shall be performed as part of warranty.

2. System shall not be accepted until completed demonstration forms and checklists are submitted and approved as required.

3.20 CLEANING

1. Each day clean up debris resulting from work. Remove packaging material as soon as its contents have been removed. Collect waste and place in designated location.

2. On completion of work in each area, clean work debris and equipment. Keep areas free from dust, dirt, and debris.

3. On completion of work, check equipment furnished under this section for paint damage. Repair damaged factory-finished paint to match adjacent areas. Replace deformed cabinets and enclosures with new material and repaint to match adjacent areas.

3.21 TRAINING

1. Provide training for a designated staff of Board's representatives. Training shall be provided via self-paced training, web-based or computer-based training, classroom training, or a combination of training methods.

2. Training shall enable students to accomplish the following objectives:

   .1 Proficiently operate system
   .2 Understand control system architecture and configuration
   .3 Understand DDC system components
   .4 Understand system operation, including DDC system control and optimizing routines (algorithms)
   .5 Operate workstation and peripherals
   .6 Log on and off system
   .7 Access graphics, point reports, and logs
   .8 Adjust and change system setpoints, time schedules, and holiday schedules
   .9 Recognize common HVAC system malfunctions by observing system graphics,

trend graphs, and other system tools
.10 Understand system drawings and Operation and Maintenance manual
.11 Understand job layout and location of control components
.12 Access data from DDC controllers
.13 Operate portable operator's terminals
.14 Create and change system graphics
.15 Create, delete, and modify alarms, including configuring alarm reactions
.16 Create, delete, and modify point trend logs (graphs) and multi-point trend graphs
.17 Configure and run reports
.18 Add, remove, and modify system's physical points
.19 Create, modify, and delete application programming
.20 Add operator interface stations
.21 Add a new controller to system
.22 Download firmware and advanced applications programming to a controller
.23 Configure and calibrate I/O points
.24 Maintain software and prepare backups
.25 Interface with job-specific, third-party operator software
.26 Add new users and understand password security procedures

3. Divide presentation of objectives into three sessions (1-13, 14-23, and 24-26). Participants will attend one or more of sessions, depending on knowledge level required.
   .1 Day-to-day Operators (objectives 1-13)
   .2 Advanced Operators (objectives 1-13 and 14-23)
   .3 System Managers and Administrators (objectives 1-13 and 24-26)

4. Provide course outline and materials. Provide one copy of training material per student.

5. Instructors shall be factory-trained and experienced in presenting this material. Perform classroom training using a network of working controllers representative of installed hardware.

1 - GENERAL

1.1 **GENERAL**

.1 Furnish all labor, materials, services and equipment required to make the mechanical equipment fully functional. The Work covered by this section of the specifications consists of performing all operations, including cutting, channeling, and chasing, necessary for providing power supply to the mechanical equipment forming part of this project.

1.2 **SUBMITTALS**

.1 Shop drawings shall be submitted for all equipment furnished by Contractor with internal wiring and controls, in accordance with the requirements of Section 15010.

2 - PRODUCTS

2.1 **GENERAL**

.1 All electrical materials shall be new and as listed by the Underwriter's Laboratories Canada, Inc. for the application, except as otherwise specified herein.

.2 All similar materials and equipment shall be the product of the same manufacturer or listed by an independent testing laboratory as an assembly thereof.

.3 Materials and equipment shall be the standard product of manufacturers regularly engaged in the production of such material and shall be the manufacturer's current and standard design.

2.2 **CONDUIT AND TUBING**

.1 Electrical Metallic Tubing (EMT)

.1 Mild steel, zinc-coated on the outside and either zinc-coated or coated with an approved corrosion-resistant coating on the inside.

.2 Expansion Fittings

.1 Malleable iron, hot-dipped galvanized with factory installed packing and a grounding ring.

2.3 **CONDUCTORS**

.1 Unless otherwise noted, all conductors shall be annealed copper with minimum 98% conductivity and shall conform with the applicable standards of UL, ANSI, and ICEA.

.2 Branch circuit conductors shall not be smaller than No. 12 AWG copper wire.

.3 All conductors No. 8 and larger shall be stranded.

.4 Unless otherwise specified, the minimum size for Class 1 remote-control and signal circuits shall be No. 16 AWG and for Class 2 low-energy control and signal circuits shall be No. 20 AWG.

.5 The use of solid or stranded wire shall meet the equipment manufacturer installation requirements.

.6 Unless otherwise specified, all conductor insulation shall be type THHN-THWN for 600V and below.

2.4 OUTLET, JUNCTION, AND PULL BOXES

.1 Outlet Boxes

.1 Only zinc-coated or cadmium-plated sheet-steel boxes, of a class to satisfy the conditions for each outlet, shall be used in concealed work.

.2 Boxes mounted on the outside of the building walls shall be cast construction, with threaded hubs and gasketed covers.

.3 Outlet boxes for exposed work shall not be less than 4 inches square with appropriate covers for surface work. "Handy" boxes may be utilized in accordance with the NEC requirements. Cut-in boxes are allowed to be installed for non-exposed work.

.4 Each box containing an equipment grounding conductor serving motors, lighting, fixtures, or receptacles shall be provided with a grounding terminal.

.5 A device plate shall be provided for each outlet to suit the device installed.

.6 All outlet cover plates on unfinished walls or on any surface mounted devices shall be of zinc-coated sheet metal, having rounded or beveled edges.

.7 Unless otherwise indicated, all plates on finished walls shall be of ivory- colored metal or heavy-duty (“unbreakable”) nylon.

.8 Screws shall be of metal with counter sunk heads with a finish to match the finish of the plate.

.9 The use of sectional device plates is not permitted.

.2 Junction/Pull Boxes

.1 Pull boxes shall be constructed of code-gage galvanized sheet metal not less than the minimum size recommended by the National Electrical Code.

.2 Boxes shall be furnished with screw fastened covers unless otherwise specified.

2.5 CABINETS

.1 Cabinet boxes shall be constructed of zinc-coated sheet steel and shall conform to the requirements of Underwriter's Laboratories, Inc. Standard for Cabinets and boxes (UL #50).

.1 Trims and doors shall have a suitable primer coat and a finish coat of a color specifically designated.

.2 Cabinet trim shall be fitted with hinged door and flush latch.

.3 Boxes shall be provided with a 3/4 inch exterior grade, one-faced "B" grade, or equal plywood backboard inside painted white unless otherwise specified on Drawings.

.4 Cabinets shall have their identification letters shown on engraved plastic plates as shown on Standard Drawing E-0006STD.

2.6 GROUNDING AND BONDING

.1 Grounding and bonding products, whether or not indicated on the Contract documents, shall be of sizes and ratings to comply with the NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.

.2 Grounding and bonding conductors shall be copper. Equipment ground conductors run with circuit conductors and grounding electrode conductor shall be insulated with green outer finish, unless noted otherwise on the Contract documents.

.3 Unless noted otherwise, all conductors No. 8 AWG and larger shall be stranded, Class B in accordance with ASTM B8.

.4 Uninsulated conductors shall be bare copper in accordance with ASTM B3, tinned in accordance with ASTM B33, or alloy-coated in accordance with ASTM B189.

.5 Use tinned or alloy-coated in corrosive environments.

.6 Grounding connectors shall be listed and labeled for grounding application. Connectors shall be high-conductivity, heavy-duty units.

.7 Compression Connectors: Shall comply with IEEE STD 837, ANSI/UL-467.

.8 Welded Connectors: Exothermic-welded type, in kit-form, and selected per manufacturer’s written instructions.

.9 Ground rods shall be copper-clad steel with high-strength steel core and electrolytic-grade copper outer sheath, molten welded to core. The minimum rod size shall be 3/4 inch by 10 feet long.

2.7 MOTOR CONTROLLERS (STARTERS)

.1 All controllers shall conform to the adopted standards and recommended practices of the Industrial Control Standards of the National Electrical Manufacturers' Association and the Underwriter's Laboratories, Inc.

.2 Each motor or group of motors requiring a single control shall be provided with a suitable controller and devices which will perform the functions as specified for the respective motors in other sections of these specifications.

.3 Each motor, except those whose impedance is sufficiently high to prevent over heating due to failure to start, such as clock motors, shall be provided with overload protection, either integral with the motor or controller, or mounted in a separate enclosure.

.4 Unless otherwise specified, protective devices shall be of the manual reset type. Manual controllers for motors, larger than 1/4 horsepower, shall be specifically designed for the purpose and shall have a horsepower rating adequate for the motor.

.5 Where overloads are supplied with controllers, these shall be sized after receipt of the equipment to be protected in accordance with nameplate data.

.6 Overload protection for substituted multi speed motors shall be arranged to protect all windings and shall be so designed that if an overload occurs in one winding, all windings will be disconnected simultaneously.

.7 Starters shall be full voltage, non-reversing magnetic starters. Full protection is to be provided in the starters by means of one thermal overload relay per phase per starter with manual reset button to suit the service factor and acceleration time of the motor served.

.8 Starters shall be equipped with auxiliary contacts to satisfy interlocking and automatic control requirements, “Hand-Off-Automatic” switches, pilot lights (green-On; red-Off), thermal overloads, necessary fuses and control transformer (if required) for operation of all controls on 120V single phase.

.9 Where required by applicable codes, starters shall be equipped with “quick-make” and “quick-break” fused disconnects.

.10 Standard of Acceptance:

.1 Square D Co. Ltd.
.2 Allen-Bradley Canada Ltd.
.3 Westinghouse Canada Inc.

.11 Fuses in starters to be CSA certified Form 1, current and energy limiting type 200,000 ampere interrupting capacity with NEMA Class “J” rejection type mountings.

.12 Size fuses installed in starters or in disconnect switches used in conjunction with magnetic starters, for motor and branch circuit protection in accordance with fuse

manufacturer's recommendations. Provide one spare set of three fuses for each rating and type of fuse used.

.13 Enclosures for loose starters are to be EEMAC 1A, unless otherwise specified.

2.8 PANEL BOARDS

.1 Panel boards shall be provided from the following approved manufacturers:

.1 Cutler-Hammer.
.2 GE.
.3 Siemens.
.4 Square D.

.2 Ampere interrupting capacity (AIC) as indicated on panel schedules. Series AIC ratings will not be accepted.

.3 Main circuit breaker (MCB) or main lug only (MLO) as indicated on panel schedules; double or dual main lugs or subfeed lugs are not acceptable.

.4 Panel boards shall be in a single enclosure; two section panels are not acceptable.

.5 Provide panelboards with size and number of single, double, or three-pole circuit breakers as indicated on panel schedules.

.6 Arrange and number circuit breakers exactly as shown on drawings and panel schedules. Single-branch mounted or subfeed breakers are not acceptable.

.7 Where the word "space" occurs on panel schedules, provide all necessary hardware in the space, including connection straps, mounting brackets, and filler plates so that only the addition of a future circuit breaker is required. Connection straps shall be rated a minimum of 100A in panelboards of 400A rating or less and a minimum of 225A in panel boards above 400A rating, unless otherwise noted on panel schedules.

.8 Provide Micarta buttons, small window-frame, or permanent strip type identification labels on interior trim to identify circuit number. Do not use adhesive-backed fabric or paper labels alone.

2.9 ENCLOSURES

.1 Shall be NEMA type enclosure as indicated on panel schedules.

.2 Provide flush or surface cover, as indicated on panel schedules.

.3 Front cover shall be factory manufactured, UL/NRTL listed, one-piece, hinged "door-in-door" type with:

.1 Interior hinged door with hand-operated latch or latches as required to provide access to circuit breaker operating handles only; not to energized parts.

.2 Outer hinged door to provide access to the entire enclosure including deadfront and all wiring gutters.

.4 Outer door shall be securely mounted to the panelboard box with factory bolts, screws, clips or other fasteners requiring a tool for entry; hand operated latches are not acceptable.

.5 Both inner and outer doors shall open left to right.

.6 Include one-piece, removable, inner deadfront cover, independent of the panelboard cover.

.7 Provide enclosure with the following side gutter dimensions:

.1 Left side minimum 4-1/2" measured from inside lip of the box to the installed deadfront.

.2 Right side; minimum 4-1/2" measured from inside lip of the box to the installed deadfront. With the door-in-door cover in place; minimum 3-1/4" from installed outer door hinge to the installed deadfront.

.8 Prepare, prime, and paint front trim cover with light gray enamel electro-deposited over phosphatized steel, or baked-on polyester coating.

2.10 BUS

.1 Phase buses shall be hard-drawn 98 percent conductivity copper.

.2 Neutral Bus:

.1 Shall be hard-drawn 98 percent conductivity copper.
.2 Shall be 100% rated (current rating same as phase buses).
.3 Shall provide a screw terminal for each breaker position, in addition to the feeder neutral lug.

.3 Grounding Bus:

.1 Shall be hard-drawn 98 percent conductivity copper.
.2 Shall be factory-installed, bonded to enclosure.
.3 Shall provide a screw terminal for each breaker position, in addition to the feeder grounding conductor lug.

2.11 CIRCUIT BREAKERS

.1 Provide circuit breakers as integral components of panel board with indicated features, ratings, characteristics, and settings.

.2 Each circuit breaker shall be bolted into position in the panel board, whether by direct bolted connection to the bus or by being bolted to the panel board frame. Each circuit breaker shall be replaceable without disturbing adjacent units. Plug-on circuit breakers

held in place only by spring force of the bus lug and the pressure of the deadfront are not acceptable.

.3 Molded-Case Circuit Breakers:

.1 Characteristics: Frame size, trip rating, voltage, frequency, number of poles, and short-circuit interrupting capacity rating as indicated on panel schedules.
.2 Tripping Device: Quick-make, quick-break toggle mechanism with inverse-time delay and instantaneous overcurrent trip protection for each pole.
.3 Multi-pole molded-case circuit breakers shall include common internal tripping of all poles.
.4 Circuit breakers with “handle-ties” are not acceptable.
.5 Half-size circuit breakers with two circuits occupying a single position on the same phase bus are not acceptable.
.6 Terminal Lugs: Provide load side of circuit breaker with front-connected UL-listed lugs for copper cable at full frame rating. Provide terminals rated for minimum 75 degrees C.
.7 All single-pole circuit breakers shall be switching duty rated.
.8 All multi-pole circuit breakers shall be HACR duty rated.
.9 Provide factory-installed circuit breaker handle padlocking devices on all multi-pole circuit breakers.

3 - EXECUTION

3.1 **GENERAL**

.1 No employer shall permit an employee to work in such proximity to any part of an electric power circuit that the employee could contact the electric power circuit in the course of work, unless the employee is protected against electric shock by de-energizing the circuit and grounding it or by guarding it effectively by insulation or other means.

.2 Fabrication, erection and installation per National Electrical Installation Standards and the complete electrical system shall be done in a first-class workmanlike manner by qualified personnel experienced in such work.

.3 Conduit and equipment shall be level, plumb and true with the structure and other equipment, and in a horizontal or vertical position as intended.

.4 The installation shall comply with all provisions of the National Electrical Code (NEC) (NFPA 70). Immediately prior to acceptance, Contractor shall clean all electrical equipment, both on the exterior and interior.

3.2 **CONDUIT AND TUBING INSTALLATION**

.1 Conduit systems that are 2” or larger, installed out doors and terminate on an exterior enclosure that houses an over-current device (circuit breakers or fuses) shall enter through the side or bottom.

.2 Electrical metallic tubing (EMT) shall not be installed in concrete, underground, or through roof penetrations. EMT may be used on the exterior of buildings unless otherwise specified on the drawings.

.3 EMT shall utilize ULC-listed water-tight compression-type threadless fittings in outdoor applications.

.4 EMT box connectors shall be securely fastened to all boxes and cabinets with one locknut.

.5 Provide liquid-tight flexible conduit in exterior, wet or damp locations, for connections to wet-pipe mechanical systems or where specified on Drawings.

.6 All EMT, IMC, and rigid conduit couplings will be installed wrench tight; threads shall be brushed clean to ensure good electrical contact.

.7 Exposed conduits shall be run parallel and perpendicular to the building surface of exposed structural members and follow the surface contours as much as practical to present a neat appearance. Exposed parallel or banked conduits shall be run together to provide neat appearance.

.8 Bends and Offsets shall be avoided where possible, but when necessary, shall be made with an approved hickey or conduit-bending machine. The use of pipe tee or vise for bending conduit or tubing will not be permitted.

.9 Conduit or tubing which has been crushed, wrinkled, or deformed in any way shall not be installed.

.10 Each conduit that is buried in or rigidly secured to the building construction on opposite sides of a building expansion joint and each long run of exposed conduit that may be subjected to excessive stresses shall be provided with an expansion fitting.

.11 Contractor shall exercise the necessary precautions to prevent the lodgment of dirt, plaster, or trash in conduit, tubing, fittings, and boxes during the course of installation.

.12 Care shall be taken to ensure that raceways do not contain any type of debris. A run of conduit or tubing, which has become clogged, shall be entirely freed of these accumulations, or shall be replaced.

.13 All empty conduits shall have a conduit measuring tape cord (Greenlee #435) provided with 2 feet of slack at each end, unless otherwise shown on plans.

3.3 SUPPORTS/ANCHORS

.1 Runs of conduit or tubing shall have supports spaced not more than 5 feet apart, unless shown otherwise.

.2 Conduit and tubing shall be supported on approved types of galvanized wall brackets, ceiling trapeze, strap hangers, or pipe straps, secured by means of toggle bolts on hollow masonry units, expansion bolts in concrete or brick, machine screws on metal surface, and wood screws on wood construction. Conduit and tubing shall not be hung from or attached to hanger support wires used for suspended ceilings.

.3 Conduit and tubing risers, exposed in wire shafts, shall be supported at each floor level by means of approved U-clamp hangers.

.4 All metal angles, channels, straps, and other similar pieces to be used to support electrical apparatus shall have all corners ground smooth and all edges filed or ground smooth before installation.

3.4 CONDUCTORS

.1 Power conductors shall be continuous from outlet to outlet, and no splices shall be made except within outlet or junction boxes. (Junction boxes shall be utilized where required).

.2 Requirements of the NEC (2002) Articles 374.6 and 390.6, for splicing in underfloor raceways, shall be strictly followed. However, under no circumstances shall conductors be "Looped" or "fed-through." Conductors shall be removed back to the nearest used tap. NEC (2002) Articles 374.7 and 390.7 for abandoned outlets shall also be strictly followed.

.3 Conductor color coding as per Standard Drawing E-0006STD shall be limited to all new installations unless otherwise specified on Drawings.

.4 Splices and Terminations

.1 For wiring below 600 volts, splices shall be made with insulated pressure type connectors (wire nuts) except for conductors sized No. 8 and larger. No splices will be allowed on any alarm, communication or facility control systems.

.2 All splicing connectors shall be furnished with an insulated cover that is equivalent to the conductor insulation. (Taping alone will not be acceptable.) Split bolt connectors will only be allowed where specific approval for each use is obtained prior to use from the Owner.

.3 A connector aid compound shall be used at all splices to existing aluminum wire.

.4 Terminal lugs shall be used on all stranded conductors.

.5 Conductor Identification

.1 All conductors in panels shall be tagged, including neutral and ground conductors. Install a Bradey slip on label on conductors sized less than # 6 AWG and install a Panduit #MP-350C tag and tie wrap on conductors sized # 6 AWG or larger. Use a Panduit marking pen PX-O or a Sharpie permanent marker for labels. These tags shall list the circuit number.

.2 All conductors shall be additionally tagged in every box and cabinet, including device or fixture (lighting) outlet, and light fixture compartment, with Brady slip on labels. Wrap around stick on labels are allowed only where slip-on labels cannot be used. These labels shall identify each conductor as to panel and circuit number or terminal numbers.

.3 Neutral and grounding conductors shall be similarly tagged as to all the circuits they serve in each box and at the panelboard.

3.5 CABINETS

.1 Mount cabinets plumb and rigid without distortion of box.

.2 Arrange flush mounted cabinets so that the enclosure front surface is uniformly flush with wall, and exterior door covers wall to enclosure mating surfaces.

.3 If not shown on drawings, stub a minimum of four one-inch (25mm) empty conduits from cabinet into accessible ceiling space or space designated to be ceiling space in future.

.4 If not shown on Drawings, stub a minimum of four one-inch (25mm) empty conduits into raised floor space, or below slab other than slabs-on–grade.

.5 All surface mounted cabinets located on finished walls within office and light laboratory areas shall be furred from the floor to the ceiling to provide a chase for conduits. The panels used for furring shall be removable by sheet metal screws or wood screw attachment or a similar method.

3.6 GROUNDING AND BONDING

.1 As a minimum, grounding and bonding shall comply with NFPA 70 (NEC), and as shown on Drawings.

3.7 CUTTING AND PATCHING

.1 Work shall be carefully laid out, in advance, and where cutting, channeling, chasing, or drilling of floors, wall partitions, ceiling, or other surfaces is necessary for the proper installation, support, or anchorage of the conduit, raceways, or other electrical work, the affected areas shall be repaired by skilled mechanics of the trades involved, at no additional Contract cost.

3.8 INTERRUPTION OF ELECTRICAL UTILITIES

.1 Work to be performed during an interruption of electrical utilities will be preceded by all possible preparation and will be carefully coordinated to minimize the duration of the interruption and Work will proceed continuously until the system is restored to normal.

.2 Contractor shall not interrupt any main interior or exterior electrical utility without written request for an outage and subsequent approval by the Owner nor shall the Contractor

interrupt any branch circuit to an outlet or item of equipment without approval from the Board.

.3 Written request for outages shall be submitted using the Outage Request Worksheet, according to the instructions and advance notice requirements on the Worksheet.

.4 Unless otherwise noted on Drawings, or directed, any tie-ins or connections to existing utilities or equipment that necessitate interruptions of service shall be performed on a Saturday or Sunday, without additional Contract costs.

3.9 TESTS/INSPECTIONS

.1 After the system installation is complete and at such time as directed by the Owner, Contractor shall conduct an operating test for approval.

.2 Also, when requested, Contractor shall test any designated wire, cable devices, and equipment after their installation, to assure that all of the material continues to possess all the original characteristics, as required by all governing codes and standards listed in these specifications.

.3 Provide an ESA inspection certificate for all new electrical work completed under this project.