Part 1 General

1.1 INTENT

.1 Provide complete, fully tested and operational mechanical systems to meet requirements described herein and in complete accord with applicable codes and ordinances. Include all costs to obtain all permits and to pay for all fees and charges, including inspection charges by the authorities that issue the permits. Coordinate all related inspections.

.2 Contract documents of the Specifications and Drawings are generally diagrammatic and approximately to scale unless detailed otherwise. They establish scope, material and installation quality and are not detailed installation instructions.

.3 Follow manufacturer's recommended installation details and procedures for equipment, supplemented by requirements of Contract Documents. Provide adequate access space for maintenance and service.

.4 Install material and equipment generally in locations and routes shown, close to building structure with minimum interference with other services or free space. Remove and replace improperly installed equipment as determined by the Contract Administrator.

1.2 WARRANTY

.1 Furnish a written guarantee stating that all Work executed in this Contract will be free from defective workmanship and materials for a period of one (1) year from the date of substantial performance of Work. The Contractor shall repair and replace any Work which fails or becomes defective during the term of the guarantee/warranty, providing the operating and maintenance instructions have been complied with. The period of guarantee specified shall not, in any way, supplant any other guarantees of a longer period provided by Manufacturers or as called for in the project documents.

1.3 THE CITY'S REQUIREMENTS DURING WARRANTY

.1 Unless specified otherwise the City shall be responsible for all routine maintenance requirements as required in the manufacturer's instructions.

.2 The City shall be responsible for supplying filters, grease and belts.

1.4 RELATED REQUIREMENTS

.1 Procurement and Contracting Requirements Division 00

.2 General Requirements Division 01

.3 Submittal Procedures Section 01 33 00

.4 Temporary Utilities Section 01 51 00

.5 Execution Requirements Section 01 73 00

1.5 METRIC CONVERSION

.1 All units in this division are expressed in SI units. Soft metric conversions are used throughout.

.2 Submit all shop drawings and maintenance manuals in SI units.

.3 On all submittals use the same SI units as stated in the specification.

.4 Equivalent Nominal Diameters of Pipes - Metric and Imperial

.1 Where pipes are specified with metric dimensions and only Imperial sized pipes are available, provide equivalent nominal Imperial sized pipe as indicated in the table, and provide adapters to ensure compatible connections to all metric sized fittings, equipment and piping.

.2 When CSA approved SI Metric pipes are available and are provided, the Contractor shall provide adapters to ensure compatible connections between the SI Metric pipes and all new and existing pipes, fittings, and equipment.

.3 Record accurately on "as-built" drawings the type of pipe (i.e., Metric or Imperial) installed.

EQUIVALENT NOMINAL DIAMETERS OF PIPES

mm	Inches	mm	Inches	mm	Inches
3	1/8	65	2-1/2	375	15
6	1/4	75	3	450	18
10	3/8	100	4	500	20
15	1/2	125	5	600	24
20	3/4	150	6	750	30
25	1	200	8		
30	1-1/4	250	10		
40	1-1/2	300	12		
50	2				

.5 Metric Duct Sizes

.1 The metric duct sizes are expressed as 25 mm = 1 inch.

1.6 COORDINATION OF WORK

.1 Cooperate and coordinate with other trades on the project.

.2 Make reference to electrical, mechanical, structural and architectural drawings when setting out Work. Consult with respective Divisions in setting out locations for ductwork, equipment, and piping, so that conflicts are avoided and symmetrical even

spacing is maintained. Provide coordination drawings showing the Work of all trades and Contractors involved, in areas of potential conflict or congestion, as requested by Contract Administrator at no additional cost.

.3 Where dimensional details are required, Work with the applicable architectural and structural drawings.

.4 Full size and detailed drawings shall take precedence over scale measurements from drawings.

1.7 CUTTING AND PATCHING

.1 Provide inserts, holes and sleeves, cutting and fitting required for mechanical Work. Relocate improperly located holes and sleeves.

.2 Provide inserts or drill for expansion bolts, hanger rods, brackets, and supports.

.3 Obtain written approval from Contract Administrator before drilling, coring, cutting or burning structural members. Ensure post tensioned or pre-stressed strands are located accurately and avoid with an adequate margin of safety.

1.8 ACCESS DOORS

.1 Provide access doors for maintenance or adjustment purposes for all mechanical system components including:

.2 Valves

.3 Volume and splitter dampers

.4 Fire dampers

.5 Cleanouts and traps

.6 Controls, coils and terminal units

.7 Expansion joints

.8 Filters

.9 Strainers

.10 Steel frame access panel with stainless steel piano-type hinge, channel reinforced steel door panel, three "Symmons" fasteners per door. Door panel recessed to receive ceiling or wall material to give finished appearance showing only hinge and fasteners. Provide acoustic gasket between door panel perimeter and steel frame. Rated access doors shall be UL-listed.

.11 Sizes to be 200 mm x 200 mm for cleanout, 300 mm x 300 mm for hand 600 mm x 600 mm for body access minimum.

.12 Provide ULC-listed fire rated access doors installed in rated wall and ceilings.

1.9 FIRE-STOPPING AND SEALING

.1 Fire-stop all pipe, duct, conduit and wire penetrations through floors and walls, designated as fire and/or smoke separations. The Contractor is required to coordinate with the architectural drawings to contractual rated wall types and installation details.

1.10 PIPE SLEEVES

.1 Pipe sleeves through exterior walls shall be of SCH 40 316L stainless steel pipe and shall be, unless detailed otherwise, one size larger than the penetrating pipe for 100 mm and larger pipe, and two sizes larger for pipe smaller than 100 mm.

.2 Process pipes passing through concrete walls shall be SCH 40 316L stainless steel with a diameter equal to the process pipe. These sleeves shall be puddle flanged and be flanged for a bolted pipe connection each end as indicated on the Drawings.

.3 Pipe sleeves shall have a 50 mm by 10 mm thick steel ring continuously welded all around the middle of the pipe length.

.4 Special sleeves shall be as shown on the drawings.

1.11 PIPES THROUGH FLOORS AND WALLS

.1 Provide stainless steel pipe sleeves where pipes pass through floors and walls (PVC, tin, or blocked out sleeves are only acceptable where indicated on the drawing).

.2 Install sleeves flush at walls and projecting at floors as detailed or 50 mm above floor surfaces and flush with bottom.

.3 Provide continuously welded rings on pipes passing through walls below grade or where walls are watertight. The thrust/seepage rings shall be as detailed on the drawings.

.4 Coat surfaces of stainless steel in contact with concrete with bitumastic.

.5 Where electrical insulation from concrete rebar is required, use link seals with pipe sleeves where shown on drawings.

.6 Where thrust restraint is required design according to AWWA Manual M11 or as detailed.

.7 There shall be no direct contact between structural steel and stainless steel.

.8 Seal space between sleeves and pipes with non-hardening mastic -Daraseal-A or approved alternative.

1.12 CERTIFICATE OF SUBSTANTIAL PERFORMANCE

.1 Refer to General Conditions and Supplementary Conditions.

.2 Prior to application for a "Certificate of Substantial Performance" of the Work, the Contractor shall certify the following in writing to the Contract Administrator:

.1 The systems are installed and suitable for operation for the purpose intended.

.2 Heating ventilation and cooling systems are capable of operation with safety devices and alarm controls functional and automatic controls in operation and the Citys personnel have had their initial training programs.

.3 All equipment within mechanical rooms is installed.

.4 All unit heaters, cabinet unit heaters, and fan coil units are installed and electrical connection made.

.5 All fans, pumps and equipment are installed and electrical connections made.

.6 All Contractor system start-up and test sheets have been completed and submitted for review.

.7 All fire stop flaps, fire dampers, and smoke dampers are installed and checked for operation.

.8 All ducted supply/return/exhaust grilles are installed.

.9 All supply air, return air, exhaust air, fresh air, and combustion air ductwork is installed and cleaned.

.10 All thermal and acoustic insulation is installed.

.11 All static pressure tests are complete.

.12 All access doors are suitably located, and equipment easily accessible.

.13 All piping is installed, painted and clearly identified complete with flow arrows.

.14 Systems are chemically cleaned, flushed, and water treatment initiated.

.15 Temporary filters are installed and fan plenums cleaned.

.16 All equipment is checked for operation, alignment amperage draw and rotation.

.17 Rough balance of air and water systems is completed and the reports have been submitted for review.

.18 All equipment is lubricated as per manufacturer's data.

.19 All valves are tagged, terminal air boxes are identified and numbered, and all equipment identified. Painting of equipment is completed and escutcheons are installed.

.20 All necessary tests and start-up procedures on equipment have been made, including those required by authorities.

.21 The building automation system seven (7) day acceptance test has been successfully completed.

.22 All building fire protection sequences for stairwell pressurization, fan shutdown, area of refuge and smoke control have been tested and certified as complete by the local authority.

.23 Following information has been submitted:

.1 Final draft of O & M Manuals.
.2 Final certificates from authorities having jurisdiction.
.3 System cleaning reports.
.4 Reports from manufacturer on noise and vibration control devices.
.5 Completed record drawings.

.3 Identify any systems which cannot be installed and/or placed in operation for reasons beyond the normal control of the Contractors and submit a statement of the value of the remaining Work required to complete the project.

.4 Within ten (10) days of receipt of a written application for a "Certificate of Substantial Performance", the Contract Administrator shall visit the Site.

.5 If, after the Contract Administrator's Site visit the application for a "Certificate of Substantial Performance" is not approved, the Contractor shall reapply in accordance with the Contract Administrator's Site visit report and pay for costs of re-inspection services.

1.13 CERTIFICATE OF TOTAL PERFORMANCE

.1 Refer to General Conditions and Supplementary Conditions.

.2 Prior to application for a statement of "Total Performance", the Contractor shall certify the following in writing to the Contract Administrator:

.1 All items noted in previous Site visit reports including that performed for Substantial Performance have been completed.
.2 All controls have been calibrated and set.
.3 Warranty forms are mailed to manufacturer. (Provide copy of original warranty for equipment which has a warranty period of longer than one year).
.4 All equipment has been aligned by qualified millwrights.
.5 Temporary filters are removed and permanent filters are installed.
.6 Completed and accepted Operating and Maintenance (O & M) Manuals have been submitted to The City.

.7 Completed and accepted final air and water Balancing Reports have been included in the O & M Manuals.

.8 The City has received instructions in the operation and maintenance of the system.

.3 Within ten (10) days after receipt of a written application for a "Certificate of Total Performance", the Contract Administrator shall visit the Site.

.4 The Contract Administrator shall provide one (1) visits for the purpose of reviewing the application for a "Certificate of Total Performance". Subsequent visit if required, shall be at the expense of the Contractor.

1.14 SHOP DRAWINGS

.1 All shop drawing submittals shall be of one original copy [sepia if larger than 275 mm (11”) x 425 mm (17”)] and **[**six (6) printed copies. Only the original shop drawing will be returned to the Contractor. Identify materials and equipment by manufacturer, trade name, and model number. Include copies of applicable brochure or catalogue material. Do not assume applicable catalogues are available in the Contract Administrators office. Maintenance and operating manuals are <u>not</u> suitable submittal material. Space must be left on the shop drawing to accommodate the Engineer’s review stamp. Where equipment is identified by name or number on the drawings or specification, clearly mark each shop drawing with the identical name and/or number.

.2 Clearly mark each sheet of submittal material (using arrows, underlining, or circling) to show differences from what is specified, particularly sizes, types, model numbers, rating, capacities, and options actually being proposed. Cross out non-applicable material. Specifically note on the submittal specified features such as special tank linings, pump seals, materials or painting.

.3 Include dimensional and technical data sufficient to check if equipment meets requirements. Include wiring, piping, service connection data and motor sizes.

.4 Prior to submission to the Contract Administrator, the Contractor shall review all shop drawings. By this review, the Contractor certifies that he has determined and verified all field measurements, field construction criteria, materials, catalogue numbers and similar data, and certifies that he has checked and coordinated each shop drawing with the requirements of the Work of the Contract documents. The Contractor's review of each shop drawing shall be indicated by stamp, date and signature of a responsible person.

.5 Installed materials and equipment shall meet specified requirements regardless of whether or not shop drawings are reviewed by the Contract Administrator.

.6 The shop drawing review by the Contract Administrator will provide the following certification: "Review by the Contract Administrator is for the sole purpose of ascertaining general conformance with design. Contractor is responsible for dimensions, fabrication and construction methods, coordination of subtrades, detail design of components, and errors or omissions on shop drawings."

.7 Submittals shall be made in BOTH metric and imperial units. Units of measure (L/s, kPa, kW, etc) shall match those noted on the equipment schedules.

1.15 TEMPORARY HEAT

.1 Prior to the use of the building systems for temporary heat the Contractor shall provide a proposed temporary heat agreement to the City for review.

.2 The agreement shall include payment schedule for utilities, spare parts listing and confirmation of warranty.

.3 Do not use the permanent system for temporary heating purposes without written permission from the Contract Administrator.

.4 Thoroughly clean and overhaul permanent equipment used during the construction period, replace worn or damaged parts before final inspection.

.5 Use of permanent systems for temporary heat shall not modify terms of warranty. Equipment Manufacturers shall certify that equipment is in "new" condition at start of warranty period.

.6 Operate heating systems under conditions which ensure no temporary or permanent damage. Operate with proper safety devices and controls installed and fully operational. Operate systems only with treated water as specified.

.7 Air systems may not be used for temporary heating.

.8 When permanent systems are used for temporary heat, provide alarm indicating system failure. (Connect alarm to independent alarm company system).

.9 Where pumps are used for temporary heating, replace mechanical seals, regardless of condition, with new mechanical seals, prior to Total Performance.

.10 Avoid thermal shock to heating system during planning, construction and operation of temporary heating system. Review procedures with the Contract Administrator.

.11 Obtain approval from the Contract Administrator for thermal insulation Work and automatic control equipment associated with temporary heating system. Have temporary heating system approved by Boiler Protection Branch of Department of Labour.

1.16 EQUIPMENT PROTECTION AND CLEAN-UP

.1 Protect equipment and materials in storage on Site during and after installation until final acceptance. Leave factory covers in place. Take special precautions to prevent entry of foreign material into working parts of piping and duct systems.

.2 Protect equipment with polyethylene covers and crates.

.3 Operate, drain and flush out bearings and refill with new change of oil, before final acceptance.

.4 Thoroughly clean piping, ducts and equipment of dirt, cuttings and other foreign substances.

.5 Protect bearings and shafts during installation. Grease shafts and sheaves to prevent corrosion. Supply and install necessary extended nipples for lubrication purposes.

1.17 TEMPORARY OR TRIAL USAGE

.1 Temporary or trial usage requested by the City of mechanical equipment supplied under Contract shall not represent acceptance. Operate and maintain all equipment and systems during trial usage.

.2 Repair or otherwise rectify damage caused by defective materials or workmanship during temporary or trial usage.

.3 For all ventilation systems, the operation of the system shall be pre-tested by running the units in a 100% fresh air, 100% exhaust air mode once all distribution ductwork is installed.

Part 2 Products

Not Applicable.

Part 3 Execution

Not Applicable.

Part 1 General

1.18 SCOPE

.1 This specification covers horizontal, 3-phase, integral horsepower, totally enclosed fan-cooled severe service, squirrel cage induction motors in the NEMA frame sizes 143T-449T.

1.19 STANDARDS

.1 All motors shall be in accordance with NEMA Standard MG-1, CSA C3900-1993, or the latest revision insofar as it is applicable. Motors also shall comply with the applicable portions of the Canadian Electric Code. Motors designed to IEC Standards are not acceptable.

.2 Motors driven by VFD equipment shall be 100% compatible to drive manufacturer's data.

1.20 ELECTRICAL REQUIREMENTS

.1 Voltage and Frequency

Motors will be rated for operation on a 3-phase, 60 Hz power supply at 575 Volts or 460 Volts or 208 Volts. All motors shall be designed and manufactured to operate with ±10% voltage and ±5% frequency variations of the nameplate ratings. Combined voltage and frequency variation shall not exceed ±10%. Confirm voltage for all motors with Division 26.

.2 Operating Characteristics

.1 Torques

Motors shall meet or exceed the locked rotor (starting) and minimum breakdown torques specified in NEMA standard for Design B for the ratings specified.

.2 Currents

Locked rotor (starting) currents shall not exceed NEMA Design B maximum values for the specified rating. Motors shall be capable of a 20 second stall at six times full load current without injurious heating to the motor components.

.3 Efficiency

Motors shall be Premium Efficient design and have a minimum and nominal full load efficiency which will meet or exceed the values listed in NEMA MG1-12.55 Table 12-6B when tested in accordance with NEMA test standard MG1-12.54.1, IEEE Test Procedure 112, Method B using accuracy improvement by segregated loss determination including stray load loss measurements. The minimum efficiency shall be guaranteed.

.4 Power Factor

The power factor of 3600 and 1800 rpm, 3 through 186.5 kW (250 HP) ratings at full load, at full voltage shall be a minimum of 85%. Six-pole ratings will be excluded from this requirement.

.3 Service Factor and Ambient

Standard motors will be rated for a 1.15 service factor in a 40°C (104°F) ambient.

.4 Insulation

.1 Standard motors shall have a full Class F non-hygroscopic insulation system.

.2 Standard motors shall be dipped and baked in polyester varnish to consolidate the winding.

1.21 MECHANICAL CONSTRUCTION

.1 Frame Size

.1 Horsepower/frame relationship shall conform to the latest NEMA standard for T-frame motors.

.2 Motors covered by this specification will be 143T-449T frame sizes.

.2 Motor Type

.1 TEFC Totally Enclosed Fan Cooled: The motor shall be designed so as to prevent the free exchange of air between the inside and outside of the motor housing. An integral fan shall be provided to direct cooling air over the exterior surface of the frame. The fan shall be one piece constructed of a corrosion-resistant material. The fan covers shall be constructed of pressed steel for frames 140T-400T and of Cast iron for 440T frames. The motor frame and end brackets shall be cast iron construction and shall have a stainless steel nameplate. Two drains shall be provided in the lowest point in the frame.

.3 Bearings

.1 All motors shall have anti-friction bearings, sized for L-10 life of at least 50,000 hours under minimum V belt heave sizes for maximum loading conditions (see NEMA Standard MG1-14.41 Table 14-1) or 150,000 hours L-10 life for a direct connected load.

.2 Bearings shall be double-shielded, vacuum degassed steel ball bearings selected for electric motor service.

.3 Bearing housings shall be re-greasable with provisions for purging old grease.

.4 Bearings shall be lubricated with a premium moisture resistant grease of a temperature range of -29°C (-20°F) to + 149°C (300°F).

.5 Cast iron inner bearing caps.

.6 All fasteners and motor hardware shall be zinc cadmium plated.

.7 Conduit box shall be cast iron, diagonally split and rotatable in 90 degree increments.

.1 Four (4) hex head bolts shall be used to secure conduit box to frame.
.2 Four (4) hex head bolts shall be used for the conduit box cover.

.8 External hardware shall be zinc cadmium plated to resist corrosion.

.9 External full gloss epoxy enamel paint shall withstand industrial environments.

.10 Nameplates shall be of stainless steel and stamped per NEMA Standard MG1-10.40. Nameplate information shall include the nominal efficiency value per standard MG1-12.54.2.

1.22 SUBMITTALS

.1 Submittals in accordance with Section 01 33 00 – Submittal Procedures.

.2 Submit shop drawings indicating motor manufacturer, frame size, voltage, full load amps, insulation class, motor grade, and dimensions.

.3 Submit manufacturer's recommended maintenance tasks for a one year period, based on application of the motor. Include maintenance schedules and lubrication products.

.4 Submit a copy of typical Warranty Certificate.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1 General Electric, US Motor, Baldor Century E Plus (VAV), Reliance XE

.2 Siemens PE-21, Westinghouse Optim HE, Marathon.

.3 All motors as listed are to be inverter grade.

2.2 TESTING

.1 Production Tests: Each motor shall receive a routine commercial test per NEMA MG-1.12. Prototype test reports shall be for each rating.

.2 Sound Level: The noise level of each motor shall comply with NEMA MG-1.12.49.

.3 Vibration Level: The vibration level of each motor shall not exceed those values listed in NEMA MG-1.12.05.

Part 3 Execution

3.1 VARIABLE SPEED DRIVES

.1 Motors shall be designed for operation with Variable Frequency Drives as noted on the motor schedule.

3.2 WARRANTY

.1 All motors shall be warranted three (3) years against defects in material and workmanship from date of final acceptance.

Part 1 General

1.1 SCOPE

.1 Scope of Work is to provide variable frequency drives complete with controls for HVAC equipment as identified in the motor schedule.

.2 Coordination with the Contractor, delivery dates, equipment start up and technical support for the installing Contractor.

.3 All drives and ancillary components specified in this section and Section 22 05 04 to be supplied by one manufacturer to assure a properly coordinated system.

.4 Design all equipment using modularized solid state equipment to allow easy maintenance and replacement.

1.2 RELATED WORK SPECIFIED IN OTHER SECTIONS

.1	Electric Motors	Section 23 05 03
.2	Electrical	Division 26

1.3 SUMMARY

.1 This section includes the requirements for variable frequency drives (VFD).

1.4 STANDARDS

.1 Provide variable frequency drives for mechanical systems as described herein.

.2 The adjustable frequency controller shall be designed to operate standard squirrel cage induction motor with a 1.15 SF. Harmonic loading will not exceed a motor service factor of 1.0.

.3 Products shall comply with IEEE Standard 519.

.4 VFD unit shall be ULC listed and CSA certified.

.5 VFD unit shall comply with applicable requirements of the latest standards of CSA, ANSI, IEEE, NEMA MG1 and the Canadian Electrical Code.

1.5 TESTS

.1 Factory testing

.1 VFD units are to be factory tested, including a full load heat run test, prior to shipment.

.2 Provide certified copies of production test results required by CSA and EEMAC, prior to acceptance of the equipment.

.2 Field Testing

.1 The VFD supplier shall provide on Site startup, fine tuning, commissioning and operator training.

.2 Allow for all costs and labour for as many trips as necessary to complete requirements.

.3 Conduct harmonic analysis of VFD units upon completion of fine tuning and commissioning phase of the installation for both input and output voltages and current. The harmonic analysis is to be conducted at 50%, 75% and 100% speed under normal load conditions and perform a fourier (FFT) transform analysis spectrum for each waveform covering the fundamental to the 50th harmonic for each VFD on this project.

.3 Provide certified copies of all production test results required by CSA and EEMAC.

.4 Fine tune UFD with central signal inspect, verify motor load RPM at 50%, 75%, 90% and 100%. Record all measured values.

.5 Calibrate VFD display values with Building Controls System display output. Verify motor RPM values with a calibrated tachometer. Conduct a minimum of 4 samples.

1.6 SHOP DRAWINGS

.1 Full shop drawings of all equipment to be submitted for review prior to manufacturing.

.2 Provide the following shop drawing information:

.1 Catalog and technical data.
.2 Outline dimensions, shipping section dimensions, weight, and foundation requirements for all assemblies.
.3 Control schematics.
.4 External connection diagram showing function and identification of all terminals requiring field connections.
.5 Confirm OEM motors are compatible with variable speed drive.
.6 Component fabrication drawings consisting of detailed circuit schematics, printed circuit board drawings, and chassis layouts for all electrical and electronic components.
.7 Manufacturer's certification that VFD can withstand applicable short circuit fault conditions.
.8 Manufacturer's certification that VFD can withstand environmental conditions.
.9 Bolt and lug torque schedule.

To include, but not be limited to:

a) All shop drawings information listed above.

.10 Troubleshooting charts for all device faults.
.11 An instruction manual for programming and hardware provided with the equipment at time of shipment.
.12 Setting sheets to record all VFD configuration options/selections for drive setup.

.3 Provide as built shop drawings for each unit upon completion of installation.

.4 VFD startup check sheet or list, outline all tasks.

Part 2 Products

2.1 ACCEPTABLE PRODUCTS

.1 Variable Frequency Drive (VFD) as supplied by:

.1 Siemens
.2 Hitachi
.3 BBC Brown Boveri Canada
.4 Cutler Hammer
.5 TECO-Westinghouse
.6 ABB

2.2 GENERAL

.1 Variable speed controller shall be electronic adjustable frequency and voltage output unit. The variable frequency drive shall be PWM type. All units shall be CSA approved and manufactured to CSA Z299.3.

.2 The drive shall be rated for continuous duty while operating a NEMA design induction motor of the sizes and operating voltages as shown in the following schedules and indicated on the drawings. Drive output shall be sized for a 1.15 motor service factor.

The VFD shall have a current rating at least 10% in excess of the motor full load amp rating. An overload service factor of 110% for thirty minutes or 150% for one minute duty must be supplied to ensure adequate safety margins.

.3 The VFD shall have a fixed bridge type converter (PWM) with a minimum of a 98% input displacement power factor over a 10 to 100% speed range. The efficiency shall be a minimum of 97% for all inverters when operated at full speed and load.

2.3 INPUT POWER

.1 Input voltage shall be as indicated on motor schedules and drawings, line voltage variation (±10% ±15%), 3 phase, 60 Hz, grounded power supply without high or low line tripping.

.2 Permit variations of 45 to 65 Hz of line frequency without the VFD shutting down on a fault.

.3 Permit power line interruptions for high inertia loads such as fans and centrifuges for at least 2.0 seconds without the VFD shutting down on a fault providing an extended power loss ride-through. If the drive trips on undervoltage, the drive will activate the Automatic Restart.

.4 The VFD not to exceed the notch depth of 20%, the total harmonic voltage distortion factor (THD) of 5%, total demand distortion of 1 5% and the notch area of the line-to-line

voltage to be maximum 28,500 volt-microseconds at rated voltage and current, or as specified in IEEE 519, latest edition.

.5 The VFD shall present a displacement power factor of 0.98 or better to the AC line at any speed or load. Full load effective power factor shall be 96% or better.

.6 Efficiency of VFD controller shall be not less than 97.5% at 60-hertz output when driving the specified maximum load.

.7 The variable frequency control to operate satisfactorily when connected to a bus supplying other solid state power conversion equipment which may be causing up to 5% total harmonic voltage distortion and communication notches up to 36,500 volt microseconds.

.8 The VFD not to require an input isolation transformer.

.9 The VFD not to be sensitive to supplied power that has one phase grounded (Delta) or referenced to earth ground (Wye).

.10 The VFD not to be sensitive to incoming phase sequence.

.11 The VFD to include transient voltage suppression (MOV) to allow reliable operation encountered in an industrial/commercial power distribution system for transients up to 300OV, 200 Joules, phase to phase and phase to ground.

.12 The VFD to include a 5% input line reactor filter.

2.4 OUTPUT POWER

.1 The VFD to produce a 3 phase output for the load.

.2 The VFD to be of the Pulse-Width Modulated type and to consist of a full wave diode bridge converter to convert incoming fixed voltage/frequency to a fixed DC voltage. The Pulse Width Modulation strategy shall incorporate a microprocessor to handle all Logic functions as well as the complex, sine-coded PWM generating algorithms that control output stage switching. Generate the inverter output by IGBT power transistors only.

.3 Unless otherwise specified, the standard VFD output frequency can be programmable from 0 to 66 Hz.

.4 When specified on the data sheets, frequencies of up to 1 20 Hz to be obtainable.

.5 Unless otherwise specified, the VFD output voltage to be adjustable from 0 to full voltage reaching full voltage at 60 Hz.

.6 Unless otherwise specified, the VFD to produce a constant volts-per-hertz (V/Hz) ratio in the 60 Hz range and below or use Vector Control.

.7 Unless otherwise specified, the VFD to supply a constant full voltage output when operating above 60 Hz.

.8 The volts-per-hertz output of the VFD not to be affected or require readjustment when other drive adjustments (such as maximum speed) are changed.

.9 Provide selectable constant V/Hz ratio PWM or Vector Control algorithm.

.10 When subject to the range of ambient conditions, the VFD to be capable of maintaining 100% of rated output current continuously.

.11 When subject to the range of ambient conditions, the VFD to be capable of delivering 135% of rated output current for up to one minute for variable torque loads and 150% for one minute for constant torque applications.

.12 The VFD output waveform to be the PWM or Vector type waveform producing smooth torque at low frequencies and low motor current harmonics.

.13 Programmable PWM carrier frequency.

.14 The VFD to be capable of operating with the VFD output open circuited (no motor connected), with no fault or damage for startup and testing purposes.

.15 Manufacturer to indicate, at time of tender, the anticipated levels of electrical noise and heat generated. In any case, the Audible noise levels to be less than 85 dbA at 1 m out from any point on the VFD cabinet under normal operating condition.

.16 Point of Common Coupling: Electrical noise, (radio interference and AC line harmonics) limited to levels specified in applicable standards. Equipment to be so designed that use of radio communication equipment adjacent to VFD units is permissible. In addition, the variable speed equipment not to be susceptible to interference from radio equipment operated adjacent to it. Harmonics generated by the variable speed equipment to be guaranteed not to exceed a level indicated by the manufacturer at the time of tender and in no case to be greater than 5 percent total harmonic distortion for voltage and 15 percent for current based on the equipment rating, per IEEE 519, Latest Bulletin or revision.

.17 Provision of adequate grounding within the equipment in addition to protection means for electrostatic discharge.

.18 The VFD is to be provided with output 5% reactor filter to limit dv/dt to existing motors. This requirement may be waived if the VFD vendor submits data showing output filtering is not required for protection of the motor furnished with VFD proposal. Output reactor filtering (dv/dt) is not required on 208 V – 3 phase application and on systems, which utilize NEMA MGJ-1993, Part 31 (Inverter Duty Rates Motors). Standard of acceptance: MTE Corporation, TIC Corporation).

2.5 EQUIPMENT ENCLOSURE

.1 Drive shall be provided with individual EEMAC 1 metal enclosure with hinge gasketted door, dripproof suitable for wall or free standing installation.

.2 Forced air cooled enclosures shall have filters on all air inlet openings.

.3 Filter media is to be chemical treated (tackifier) type (Air guard Filter Industries V60-PSF45 or equal in accordance with B7).

.4 The backspan to be galvanized metal, non-painted, 16 gauge for EMC bonding requirements.

.5 Door to be grounded with multi-conductor or braided ground strap.

Manufacturers standard colour unless directed otherwise.

2.6 EQUIPMENT PROTECTION

.1 Protective devices to be incorporated are:

.1 3 pole MCB or fused disconnect switch to provide overcurrent protection set at not more than 150% of drive input rating for a given motor size. Over current protector shall have (30) kA IC symmetrical rating to be coordinated with drive's electronic protection circuits. Overcurrent protection device to have lock-off facilities. Confirm IC symmetrical rating as noted on drawings.
.2 Fast acting electronic circuit board protective fuses for protection of electronic components.
.3 Line filter (MOV) in the drive input to protect electronic components from transient voltage conditions. MOV's are not to be part of the bridge circuit. MOV's to be replaceable.
.4 Integral electronic motor overload protection adjustable up to 150% of motor rating for 60 seconds.
.5 Overcurrent instantaneous trip 250%.
.6 Short-circuit protection.
.7 Ground fault protection.
.8 Overvoltage DC bus monitor/protection.
.9 Undervoltage protection, 85% of rated input voltage.
.10 Loss of phase and phase unbalance protection.
.11 Inverter over-temperature protection.
.12 Capable of running without motor.
.13 Output filter package (dv/dt) to limit motor voltage to 1200 volts maximum, at motor terminals.
.14 Long lead (motor feeder) filter package, 300 mm or longer.
.15 Thermistor relay(s) as required.
.16 Output motor HP/FLA – contactors.
.17 Primary and secondary control transformer protection.
.18 Single phase protection.
.19 Motor overload protection, adjustable 80 to 115% of FLA of motor.

2.7 OPERATION FEATURES:

.1 Fault shutdown.
.2 Automatic restart following power outage.
.3 Ability to disconnect motor load for setup or trouble.
.4 Manual speed control potentiometer.
.5 Adjustable maximum and minimum speed.

.6 Acceleration and deceleration time adjustment.
.7 Controller "stop" interlock from a NC dry contact.
.8 Hand/Off/Auto selection switch or key pad.
.9 Drive fault contact (Form C).
.10 Stop/start push buttons or key pad.
.11 Transient voltage protection.
.12 Provide three (3) dry "C" type contacts programmable for any combination of the following:
.1 Running (output frequency being generated)
.2 Fault lockout
.3 Stopped
.4 Overspeed
.5 At speed
.6 Under speed
.7 Forward/Reverse
.8 Low reference
.9 Manual/Auto Mode
.10 Local/Remote Mode
.13 Soft Start sequence

2.8 CONTROL FEATURES

.1 Provide two (2) analog inputs which are both capable of operating from 4-20 mA or 0-10VDC. Provide individually isolated inputs for each analog signal.

.2 A programmable linear or S curve suitable for all drives requiring controlled acceleration/deceleration.

.3 Provide offset and gain programmable functions to set operating range.

.4 Provide two (2) analog 0-10 VDC or 4-20 mA outputs that can be programmed to be proportional to any two of the following: Each analog outputs must be individually isolated.

.1 Output frequency
.2 Motor speed
.3 Motor torque
.4 Motor power
.5 Output current
.6 DC bus voltage
.7 Motor voltage

.5 All VFD set-up operations and adjustments to be digital and stored in a nonvolatile memory (EEPROM). No analog or potentiometer adjustments to be allowed.

.6 VFD operation to be fully digital with microprocessor control of frequency, voltage and current.

.7 The VFD to be capable of communicating with a communication device over the remote I/0 serial link, multi-drop, typically RS485, using industry standard communication

protocol. Provide software for personal computer use to upload and download parameters. Provide software with each drive on CD-ROM, 3.5 floppy or ZIP disk with all associated operating instructions.

.8 Speed Droop: Provide a speed droop feature that reduces the speed of the drive on transient overloads. The drive is to return to set speed after transient is removed. If the acceleration or deceleration rates are too rapid for the moment of inertia of the load, the drive is to automatically compensate to prevent drive trip.

.9 Speed Profile: Provide individual adjustable settings for start, stop, slope, and minimum and maximum speed points.

.10 Process Signal Inverter: Provide programmable control to allow speed of drive to vary inversely with input analog signal.

.11 Digital Interface: Provide a local interface to upload, download and read drive parameter settings through the use of a personal computer or a similar portable device.

.12 Pick up a Spinning Load (Rotating Start): The VFD shall be programmable for rotating start, enabling the VFD to start into a rotating motor, regardless of direction, without tripping and without setting the motor to zero speed. The VFD to start at the speed the motor is rotating and then accelerates the motor according to the speed reference signal.

.13 Bumpless speed transfer: Provide a bump-less speed transfer from remote control to local control and vise-versa, without setting the motor to zero speed.

.14 Automatic Reset/Restart: Provide programmable automatic reset/restart after any individual trip condition resulting from either overcurrent, over voltage, under voltage, or an over temperature.

.15 For safety, the drive shall shut down and require manual reset if the automatic reset function is not successful within a maximum of three attempts within a short time period.

.16 IR Compensation: Complete set of parameters (programmable range) which allows for extra torque to be applied at speeds between 0.1 Hz and the set field weakening point, 140% rated torque shall be produced with 1 50% rated current.

.17 Torque Compensation: The automatic boost in torque to handle impulse loads or demands for fast acceleration by momentarily increasing the output volt/hertz ratio. When selected, the function to be operative at all speeds even under overload conditions, and eliminates the motor speed droop that would otherwise occur.

2.9 EXTERNAL CONTROL AND MONITORING

.1 General: Provide isolation and voltage surge suppression for contacts used for external monitoring to limit inductive switching surges to less than 200 V peak. Provide DC coils with freewheeling diodes to limit inductive surges to 28V peak.

.2 Wiring: Use twisted shielded pairs for control and signal wiring that connects external to the VFD. Separate signal and power wiring that may contain voltage and/or current harmonics inherent to inverter.

.3 Operator Station (Front Panel)

.1 Provide an operator station on the drive door complete with the following features as a minimum:

.1 START pushbutton for local control
.2 STOP pushbutton for local control
.3 HOA Selector switch or LOCAL/REMOTE selector.
.4 Potentiometer or speed raise/power pushbuttons with digital frequency display for local speed adjustment

.2 The digital operator station to be mounted on the drive panel (i.e. MCC cubicle door) face.

.3 The keypad to read motor frequency, frequency setpoint, motor load and voltage while VFD is operating.

2.10 SPEED CONTROL

.1 The VFD to contain an independent parameter setting which provides an adjustable minimum speed setting from 0 to 60 Hz.

.2 The VFD to contain an independent parameter setting which provides an adjustable maximum speed setting from 40 to 90 Hz.

.3 The VFD to accept an isolated analog input speed reference of 0- 1 OVDC or 4-20 mA from the field.

.4 The 4-20 mA analog input speed reference signal shall be galvanically isolated. Calibration adjustments shall be provided for settings within the speed ranges specified.

.5 Selectable stopping modes of coast to stop, ramp to stop or DC brake to stop shall be programmable.

.6 Provide an adjustable skip frequency with programmable bandwidth to avoid operation in a resonant speed area.

2.11 DRIVE CONTROLS

.1 Provide control transformer, primary and secondary fuses, terminal blocks and control relay(s) interconnected in accordance with the project requirements.

.2 The VFD to accept an isolated output signal via DCS to stop and start the drive.

.3 The VFD to have the capability to interlock of up to 3N/C external interlocks to shut down the VFD and provide status of the trip.

.4 The VFD to provide 3 programmable form C dry contact outputs. Status of contacts to indicate:

.1 Run
.2 Ready
.3 Fault

.5 The Drive to be wired to achieve the following functionality: Motor selected to "Auto" ("Remote") enables the motor to be started and stopped remotely, and the speed to be adjusted via the field analog signal.

Motor selected to "Manual" ("Local") enable motor to be started, stopped and speed to be adjusted via the front panel pushbuttons and selector switches of the panel operator station.

2.12 PARAMETER SETTINGS

.1 Provide the following system configuring settings, field adjustable through the keypad/display unit or via the serial communication port.

.2 Motor configuration data:

.1 Motor frequency.
.2 Number of poles.
.3 Full load speed.
.4 Motor volts.
.5 Motor full load amps.
.6 Motor HP.

.3 VFD limits:

.1 Independent acceleration and deceleration rates.
.2 No load boost.
.3 Vmin, Vmax, V/Hz.
.4 Full load boost.
.5 Overload trip.
.6 Min/Max speed (frequency).
.7 Auto reset for load or voltage trip select.
.8 Slip compensation.
.9 Rotating Start select.
.10 Overload trip setting.

.4 Controller adjustments:

.1 Minimum frequency 0 - 60 Hz.
.2 Maximum frequency 40 - 90 Hz.
.3 Acceleration time 0.3 - 300s.
.4 Deceleration time 0.3 - 300s.
.5 Output current from 50 - 150% of nominal current for constant torque and output current of 50 - 135% for variable torque applications as a minimum.

.6 Start of motor by: Normal acceleration or automatic start boost or rotating start.
.7 Stop by: Coasting or ramp deceleration or DC braking.
.8 Slip compensation
.9 Electronic over load adjustment setting.
.10 Automatic restart after voltage trip.
.11 IR compensation boost between 15 - 45V depending on size.
.12 Linear or tapered V/Hz ratio.
.13 Selection of field weakening point (V/Hz ratio).
.14 Automatic start boost, programmable, active only at start until output frequency reaches 20 Hz or set speed reference less than 20 Hz.

.5 The digital keypad allows the operator to enter exact numerical settings. A plain English user menu shall be provided in software as a guide to parameter setting, (rather than codes). Drive parameters shall be factory set in EEPROM and be resettable in the field through the keypad. Multi levels of password security shall be available to protect drive parameters from unauthorized personnel. The EEPROM stored drive variables must be able to be transferred to new boards to reprogram spare boards.

.6 The VFD to execute, on initial power-up, a self-diagnostic check. The integral programming display panel shall provide first fault indication of VFD protection functions. Fault indication to be retained if input power is lost. The following faults to be displayed on the local programming panel:

.1 Overcurrent
.2 Short Circuit/Ground Fault
.3 Under voltage
.4 Over voltage
.5 Over temperature
.6 Power Supply Fault
.7 Motor stalled

.7 Fault codes to provide direction as to board level and input- output level to aid in trouble shooting.

.8 The fault log record shall be accessible via a RS485 serial link as well as readout on the keypad display on the panel door.

.9 Self-diagnostic check to indicate faulty internal components.

.10 Provide a trace buffer to store actual values of up to eight different programmable signals at the time of a fault trip. The information to be stored in memory to be retrieved by PC or a recorder.

.11 Diagnostic and indicating features:

.1 Power ON indication.
.2 Percentage speed indicator.
.3 Overload indication.
.4 Short circuit indication.
.5 Ground fault indication.

.6 Overvoltage indication.
.7 Undervoltage indication.
.8 High temperature (controller).
.9 AC voltmeter (output).
.10 AC ammeter (output).
.11 Inverter ready.
.12 Inverter fault.
.13 External fault.
.14 Frequency

2.13 ENVIRONMENTAL CAPABILITIES

.1 The drive shall operate without mechanical or electrical damage under any combination of conditions as follows:

.1 Ambient temperature -0° to 40°C (32°F to 105°F)
.2 Humidity 5 to 95% (non condensing).
.3 Vibration up to 0.5 G.
.4 Altitude 0 to 1000 m (0 ft to 3280 ft) For altitudes above 1000 m, the equipment must be properly derated such that the higher altitude rating is greater than the required output.

2.14 EMERGENCY DISTRIBUTION

.1 The VFD may be supplied from an emergency distribution system, which is subjected to short power interruptions during test of the emergency generator system. The VFD shall be designed to continuously operate through this test mode. Minimum time requirement 2 seconds of ride through.

.2 VFD suppliers shall verify that this condition will not cause damage to their equipment and that they will be able to ride-through this disturbance without any operational shutdowns.

2.15 CENTRAL WIRING AND IDENTIFICATION

.1 Control wiring shall be TEW 105°C (220°F) rise.

.2 Terminal blocks for remote interface shall be Weidmueller SAK6N or approved equal in accordance with B7.

.3 Provide wire markers at both ends of all control wires, Electrovert Type Z or approved equal in accordance with B7 .

.4 Provide lamicoid indicating more than one valley source, caution label regarding regenerator voltage on load side of output contactor.

2.16 MAINTENANCE

.1 VFD supplier shall provide four copies of operation and maintenance manuals.

.2 Operation and maintenance manuals are to include a list of authorized service depots, spare parts lists and recommended spare parts.

.3 VFD supplier is to include a preventative maintenance program (PMP) for a one year period. The PMP is to be broken down to daily, weekly, monthly and annual service periods. Each service period is to include all manufacturer recommended maintenance tasks which should be completed in each period. A maintenance checklist is to be cross referenced to the maintenance period and maintenance task.

2.17 WARRANTY

.1 The VFD supplier shall provide warranty coverage for a period of twelve (12) months upon the Contractor being granted Final Acceptance and the warranty period has commenced.

2.18 BYPASS

.1 Provide integral disconnect for the drive after the door interlocked fusible disconnect.

.2 Provide primary and secondary fused 1 20 Vac control power.

.3 Provide motor starter Contractor for Bypass and AFD operation. Selection of mode of operation will be via integral mounted BYP-OFF-AFD selector switch.

.4 Provide a thermal overload relay sized to protect the motor for either mode of operation.

.5 Provide a Hand-Off-Auto selector switch and a interposing relay to select the run/stop operation in conjunction with BYP- OFF-VFD switch as follows:

.6 VFD MODE:

.1 Selector switch in HAND (LOCAL) position.

VFD operated by panel mounted start and stop pushbuttons, speed controlled by the keypad.

.2 Selector switch in OFF position.

Motor cannot be started.

.3 Selector switch in AUTO (REMOTE) position.

VFD operates by remote start/stop command, the speed controlled by the isolated 4 – 20 mA signal.

.4 Bypass Mode

HAND position starts Bypass manually.
OFF position prevents motor from operating.
AUTO position allows motor to start by remote start/stop command.

NOTE: All Interlocks are in the circuit for all modes of operation.

2.19 CABLING AND GROUNDING

.1 Division 16 to provide Altcatel Drive Rx cable from VFD to designated motor load.

.2 Division 16 to provide ground conductor in each feeder conduit from motor control centre to VFD.

.3 Division 15 and 16 to provide a ground conductor in each central conduit with signal and data central cables from central system to VFD.

.4 Torque all conductors with calibrated torque wrench, including ground, line, central and feeder conductors to manufacturer recommendation.

Part 3 Execution

3.1 GENERAL

.1 The Contractor will provide the VFD manufacturer an as built of each motor application. Motor application data will include the following:

.1 Motor Manufacturer
.2 Class
.3 Motor Model #
.4 Motor Serial #
.5 Motor Frame
.6 Motor H.P. (Kw)
.7 Motor F.L.A.
.8 Motor Conductor Size
.9 Ground Conductor
.10 Length of Conductors from MCL to Motor
.11 MCC Manufacturer
.12 Motor MCP and Overload

3.2 INSTALLATION

.1 Install variable speed drives with the assistance of manufacturer in accordance with the manufacturer's specifications.

.2 Set and secure VFD assembly in place on channel bases, rigid, plumb and square to building floor and wall.

.3 Provide one hold down bolt front and rear for every 1 m linear length or portion thereof, with a minimum of 4 bolts provided.

.4 Protect against dust and damage during entire construction period.

.5 After connections have been made, vacuum-clean the interior. Hand-clean exterior and touch-up any damaged paint.

3.3 VFD SCHEDULE

.1 Refer to motor schedule on Electrical Drawings.

Part 1 General

1.1 SCOPE

.1 Secure and assemble all necessary literature describing the operation and maintenance of all equipment provided. Complete and transmit documentation for review to Contract Administrator at project milestones.

.2 Operating and Maintenance Manuals

.3 Record Drawings

1.2 QUALITY ASSURANCE

.1 Work specified in this section shall be performed by an Independent Agency specializing in this type of Work.

1.3 RELATED WORK IN OTHER SECTIONS

.1 Documentation for Plumbing Section 22 05 05

Part 2 Products

2.1 OPERATING AND MAINTENANCE MANUALS

.1 Closeout Procedures Section 01 78 00
.2 Closeout Submittals Section 01 78 00

2.2 MANUAL DIVISIONS

.1 Organize each manual into the following divisions.

.1 Operation Division
.2 Maintenance Division
.3 Contract Documentation Division

2.3 OPERATIONS DIVISION

.1 The operations division shall have all data organized into sections according to the system category with individual divider tabs as follows:

.1 AIR - Air Systems
.2 CTL - Control Systems
.3 CLG - Cooling Systems
.4 HTG - Heating Systems
.5 MIS - Miscellaneous Systems

.2 Organize data for each system category (section) into individual sub-systems. Provide an index for each system category and a divider tab for each individual system.

.3 For each individual sub-system include the following:

.1 System Description - Provide details of system type, composition, areas served, location in the building, design criteria and function of major components. All equipment arranged to operate together as one system shall be considered part of that system description. Design criteria shall, at minimum, include the following:

.1 Occupied space conditions
.2 Outdoor ambient conditions
.3 Air circulation rate
.4 Exhaust air rate
.5 Minimum outside air
.6 Building pressurization
.7 Future load allowances
.8 Standby capabilities

.2 System Schematics - Provide a system schematic showing all components comprising the central system. Identify each component using DDC system mnemonic and generic name designation. Use this equipment designation in all references to the equipment throughout the manual.

System schematics shall include: hot water heating system, chilled water cooling system, ventilation systems, heat recovery systems and geothermal heat pump system.

.3 Operating Instructions - Provide, in "operator" layman language, the specific instructions for start-up, shutdown and seasonal change over of each system component. Include exact type and specific location of each switch and device to be used in the system operation. Identify safety devices and interlocks that must be satisfied in order for the equipment to start. Also, list conditions to be fulfilled before attempting equipment start-up, i.e. valves position correct, glycol mixture concentration proper, piping filled with fluid, filters/strainers in place, etc.

.4 Equipment Identification - Provide data for each system component on equipment identification forms equal to the standard forms obtained from the design consultant.

The consultant shall provide one sample reproducible copy of a form for use by the Contractor. New forms produced by the Contractor shall follow the same format as the sample form and contain all required information.

.5 Maintenance Division

.1 Organize data into the following sections with divider tabs:

.1 Maintenance Tasks And Schedules
.2 Spare Parts
.3 Suppliers And Contractors
.4 Tags And Directories

.2 Maintenance Tasks and Schedules - Organize data according to the system category, with further breakdown into individual systems as used in the operations division of the manual. Provide section index and divider tabs for each system category. Summarize maintenance tasks from manufacturers maintenance brochures, for each component of each system in the following format:

.1 Daily
.2 Weekly
.3 Monthly
.4 Semiannually
.5 Annually
.6 When Required.

.3 Spare Part List - Organize data according to the system category, with further breakdown into individual systems as used in the operations division of the manual. Provide section index and divider tabs for each system category. Summarize from manufacturers maintenance brochures the recommended spare parts for each component of each system.

.4 Suppliers and Contractor List - Provide summary of Suppliers and Contractors for each components of each system. List name, address and telephone number of each.

.5 Tags and Directories - Provide a copy of the Mechanical Drawing, List, Valve Tag List, Piping Identification Schedule and all other directories as specified in the Contract documents.

.6 Contract Documentation Division

.1 Organize all data required by the construction Contract into sections, with divider tabs, as follows:

.1 Drawings List
.2 Shop Drawings and Product Data
.3 Certifications
.4 Warranties and Bonds
.5 Maintenance Brochures
.6 Reports

.2 Shop Drawings and Product Data - Provide <u>final</u> copies of all shop drawings and product data required by the Contract documents. Include section index and divider tabs. Maximum of twenty-five (25) sheets or one (1) system shop drawing per tab.

.3 Certifications - Provide copies of Contractor Certifications for the performance of product and systems. Include copies of all pressure tests for piping and ductwork systems, equipment alignment certificates, local authority inspection reviews, backflow prevention certification, and fire protection certifications. Include section index and divider tabs with maximum of twenty-five sheets (25) or one report per tab.

.4 Warranties and Bonds - Include one copy each of the Contractor's, warranty, manufacturers' warranties longer than one year, the bond, and any service Contract provided by the Contractor. Provided section index.

.5 Maintenance Brochures - Include copies of all manufacturers' printed maintenance brochures pertaining to each product, equipment or system. provide section index and divider tabs. Maximum of twenty-five (25) sheets or one system brochure per tab.

.6 Reports - Include copies of all reports relating to the testing, adjusting and balancing of equipment and systems, water treatment reports and manufacturer's start-up reports, as required by the Contract specification sections.

.7 Submissions and Approvals

First Draft Submission

.1 Contractor shall submit a draft copy of the operations and maintenance manuals for format review at the 50% construction completion stage.

.2 The draft submission is to be bound in 3 ring loose leaf type binders and shall include the following information:

.1 A table of contents for the complete manual.
.2 Index of each division of the manual.
.3 Index of each section of the operations and maintenance divisions.
.4 A sample operations division write-up for a typical system, including sample schematic.
.5 A sample maintenance division write-up for the same typical system.
.6 Sample proof of binder covers and spines.

.3 On completion of review of the first draft submission the Contract Administrator will return the copy of the manual with review comments for resubmission.

Provisional Edition

The Contractor shall submit two (2) copies of the provisional edition of the manual at the 75% construction completion stage.

The provisional edition shall be complete in all respects, except for reports and certificates to be produced during the facility start-up phase. This manual shall have the same physical format, including divider tabs and indices, as the final edition of the manual. This provisional edition may be bound in standard three-ring loose leaf binders.

One copy of the provisional edition shall be kept on Site as an interim reference for all parties engaged in the facility start-up phase, and shall be used to familiarize and train the operating staff.

The second copy shall be returned to the Contractor with review comments.

The Contractor shall update contents of the Site copy of the provisional edition manual as new information is generated during the facility start-up phase.

Final Edition

Prior to final acceptance the Contractor shall submit four (4) copies of the final edition of the manual.

This final edition shall include all outstanding project information and conform to all requirements listed in this document.

2.4 RECORD DRAWINGS

.1 Refer to Section 01 77 00, Closeout Procedures.

.2 The Contractor shall keep, on Site, available to the Contract Administrator at all times and particularly for each regularly scheduled Site meeting, a complete set of prints, edge bound, that are to be updated daily showing any and all deviations and changes from the Contract Drawings. This set of drawings is to be used only for this purpose, and must not be used as the daily general reference set.

.3 Provide record drawings which identify location of smoke and fire dampers, major control lines, access doors, tagged valves, and actual room names or numbers. As well, deviations that are to be recorded shall include, in general, items that are significant or are hidden from view and items of major importance to future operations and maintenance, and to future alterations and additions including cleanouts and isolation valves.

Part 3 Execution

3.1 GENERAL

.1 Submit documents to the Contract Administrator for approval prior to transmitting to the City.

3.2 RECORD DRAWINGS

.1 At substantial completion, transfer all deviations, including those called up by addenda, revisions, clarifications, shop drawings, and change orders, to a set of disks to AutoCAD/Revit. Drafting quality layers, symbols, etc. shall be identical to original drawings. Prior to substantial performance, turn over a completed set of disks and a complete set of mylar sepia record drawings.

.2 Each “record” drawings shall bear the Contractor’s identification, the date of record and the notation “We hereby certify that these drawings represent the “Work Record of Construction”. The Contractor’s signature and company seal shall be placed below that notation.

Part 1 General

1.1 SCOPE

.1 Provide meters and gauges and taps where shown on drawings and/or specified herein.

.2 Submit shop drawings of proposed products to the Contract Administrator for review.

.3 Submit data sheets on thermometers and pressure gauges indicating service, and temperature or pressure ranges, to the Contract Administrator for review.

.4 Submit list of all meters, including location, service, flow and corresponding reading for flow.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1	Pressure gauges:	Marsh, Trerice, Ashcroft, Weksler.
.2	Positive displacement meters;	Neptune, Rockwell, Badger
.3	Flow Meters:	Gerand, Preso
.4	Static pressure gauges:	Dwyer, Magnehelic
.5	Thermometers:	Marsh, Trerice, Ashcroft, Weksler.

2.2 THERMOMETERS

.1 Dial Thermometers: 50 mm (2”) **or** 80 mm (3”) diameter dial in drawn steel case, bimetallic helix actuated, brass separable socket or flange and bushing, glass cover, adjustable pointer.

.2 Mercury Thermometer: Red reading mercury filled, 2° graduations, plastic or aluminum case, 230 mm (9”) scale, straight shank, separable socket, adjustable angle.

2.3 PRESSURE/TEMPERATURE TAPS (PETE'S PLUGS)

.1 Fitting to allow a 3 mm (12 gauge) O.D. plug-in gauge to measure temperature or pressure.

.1 Maximum pressure: 3450 kPa (500 psi).
.2 Maximum temperature: 135°C (275°F).

.2 Fitting constructed of:

.1 6 mm (¼”) NPT brass body with hex head screw cap and gasket.
.2 Protective screw cap to have retaining strap.
.3 Two self-closing valves constructed of nordel.

.3 Test kit including the following:

.1 One 65 mm (2½") diameter pressure gauge with 3 mm (12gauge) O.D. plug-in stem.
.2 Two 45 mm (1¾") diameter temperature gauges with 3 mm (12 gauge) O.D. x 125 mm (5") plug-in stem, range 0 to 110°C (-32 to 230°F).
.3 All above in protective carrying case with operating instructions.

.4 Installation:

.1 Install pressure/temperature taps into threaded pipe nipples welded to wall of pipe. Locate fittings in accessible spaces.
.2 Provide one pressure/temperature taps test kit.

2.4 PRESSURE GAUGES

.1 100 mm (4") diameter, drawn steel case, phosphor bronze bourdon tube, brass movement, extruded brass socket, 1% midscale accuracy, front calibration adjustment, black figures on white background. Pressure gauges shall be liquid filled with ½% accuracy in locations subject to vibration (on pumps, air handling units, and chillers), and 1% accuracy in all other locations. Provide needle valve and syphon for steam service, pulsating damper and ball valve for water service.

2.5 STATIC PRESSURE GAUGES

.1 Dial Gauge: 100 mm (4") dial, diaphragm actuated, suitable for positive, negative, or differential pressure measurement. Accuracy within ±2% of full scale, complete with static pressure tips and mounting accessories.

.2 Inclined Vertical Manometer: molded plastic manometer, accuracy within ±3% of full scale, suitable for positive, negative or differential pressure measurement, complete with static pressure tips, and mounting accessories.

2.6 POSITIVE DISPLACEMENT METERS

.1 Nutating disc measuring chamber, disc material to suit fluid encountered, odometer-type direct reading totalizer counter with 6 numerical wheels for cumulative readings.

Part 3 Execution

3.1 INSTALLATION

.1 Install positive displacement meters with isolating valves. Provide valved bypass for liquid service meters.

.2 Install flow meters in uninterrupted straight pipe, minimum 2 pipe diameters downstream and 5 pipe diameters upstream, or according to manufacturers recommendations.

.3 Provide one pressure gauge per pump installing taps before strainers and on suction and discharge of pump. Pipe to gauge.

.4 Select gauges so that normal operating point is approximately mid-point of instrument range.

.5 On pipes 65 mm (2½") and smaller, place well in tee used in lieu of an elbow to accommodate well.

3.2 METERS AND GAUGES INSTALLATION SCHEDULE

.1 Positive Displacement Meter:

.1 Heating System Make-up
.2 Chilled Water System Make-up
.3 Glycol Charging Tank
.4 and where shown on drawings.

.2 Flow Meters:

.1 Chilled Water System
.2 Glycol System
.3 and where shown on drawings.

.3 Pressure Gauges:

.1 Boilers, (inlets and outlets)
.2 Heat exchangers, (inlets and outlets)
.3 Pumps
.4 Air Handling Units, Hydronic Heating and Cooling Coils, (inlets and outlets)
.5 Expansion Tanks
.6 Leaving side of automatic make-up valves
.7 Leaving side of pressure reducing valves
.8 and where shown on drawings

.4 Pressure/Temperature Taps - Pete's Plugs:

.1 All control sensor tappings
.2 All lines to three-way control valves
.3 Heating and cooling coils: at common inlet and outlet of each coil.
.4 All fan coils, terminal box reheat coils and duct mounted coils: at inlet and outlet.

.5 Thermometers:

.1 Boiler, (inlet and outlet)
.2 Supply and return headers of central equipment
.3 Heat exchangers, inlet and outlet tube and shell side
.4 Heating water zone supply and return mains
.5 Chilled water zone supply and return mains
.6 Air handling units, Hydronic heating and cooling coils, (inlet and outlet)
.7 Heat recovery coils, (inlet and outlet)
.8 and where shown on drawings.

.6 Static Pressure Gauges:

.1 Across built-up filter banks
.2 Across unitary filter sections
.3 Across supply and exhaust fans
.4 and where shown on drawings.

.7 Static Pressure Taps:

.1 Across all major dampers
.2 Across heating and cooling coils
.3 On each side of balance valves
.4 Across heat recovery sections
.5 and where shown on drawings.

Part 1 General

1.1 SCOPE

.1 Pipe hangers and supports.

.2 Duct hangers and supports.

.3 Flashing for mechanical equipment.

.4 Sleeving for mechanical equipment.

.5 Pipe anchors.

.6 Access Doors.

1.2 REFERENCE STANDARDS

.1 Pipe supports shall meet the requirements of ANSI B31.1 Power Piping.

.2 Duct hangers shall conform to SMACNA Duct Manuals.

1.3 GENERAL REQUIREMENTS

.1 Provide hangers and supports to secure equipment in place, prevent vibration, maintain grade, provide for expansion and contraction.

.2 Install supports of strength and rigidity to suit loading without unduly stressing building. Locate adjacent to equipment to prevent undue stresses in piping and equipment.

.3 Select hangers and supports for the service and in accordance with manufacturer's recommended maximum loading. Hangers shall have a safety factor of 5 to 1.

.4 Fasten hangers and supports to building structure or inserts in concrete construction.

.5 Provide and set sleeves or block-outs required for equipment, including openings required for placing equipment.

.6 Provide sleeves for all piping through rated assemblies. In non-rated assemblies, provide sleeves for all heating, cooling, steam, condensate, domestic hot, domestic cold, and domestic recirculation piping. Sleeves to be sized to allow insulation to pass through and to project through both sides of wall.

.7 Provide sleeves for all piping through ceilings, floors and footings.

.8 Provide sleeves for duct penetrations through walls, ceilings, floors and footings. Provide locations and dimensions for block-outs imbedded material if provided by others.

.9 Do not weld piping, ductwork or equipment supports to building metal decking or building structural steel supports unless prior written approval has been obtained from the structural Contract Administrator.

.10 Obtain approval prior to drilling for inserts and supports for piping system. Discuss and obtain approval for hanging systems and methods with Structural Contract Administrator.

.11 Obtain approval prior to using percussion type fastenings.

.12 Use of piping or equipment for hanger supports and use of perforated band iron, wire or chain as hangers is not permitted.

1.4 SUBMITTALS

.1 Submit shop drawings of each factory fabricated component.

Part 2 Products

2.1 INSERTS

.1 Inserts shall be galvanized steel shell and expander plug for threaded connection with lateral adjustment, top slot for reinforcing rods, lugs for attaching to forms.

.2 Size inserts to suit threaded hanger rods.

2.2 PIPE HANGERS AND SUPPORTS

.1 Hangers, Pipe Sizes 15 mm (½") to 40 mm (1½"): Adjustable wrought steel ring.

.2 Hangers, Pipe Sizes 50 mm (2") and over: Adjustable wrought steel clevis.

.3 Multiple or Trapeze Hangers: Steel channels with welded spacers and hanger rods. Cast iron roll and stand for hot pipe sizes 150 mm (6") and over. Cup washers for hot piping below 150 mm (6").

.4 Wall Support, Pipe Sizes to 75 mm (3"): Cast iron hook.

.5 Wall Support, Pipe Sizes 100 mm (4") and Over: Welded steel bracket and wrought steel clamp, adjustable steel yoke and cast iron roll for hot pipe sizes 150 mm (6") and over.

.6 Vertical Support: Steel riser clamp.

.7 Floor Support, Pipe Sizes to 100 mm (4") and All Cold Pipe Sizes: Cast iron adjustable pipe saddle, locknut nipple, floor flange and concrete pier or steel support.

.8 Floor Support, Hot Pipe Sizes 125 mm (5") and over: Adjustable cast iron roll and stand, steel screws and concrete pier to steel support.

.9 Design hangers so they cannot become disengaged by movements of supported pipe.

.10 Provide copper plated hangers and supports for copper piping.

.11 Provide Stainless hangers and supports for galvanized piping.

.12 Support all piping below grade and under floor slabs in 3.2 mm (10 gauge) continuous cadmium plated channel. Support channel with cadmium plated clevis hangers and rods. Install supports on centers as specified in 3.4. Extend cadmium plated hanger rods 450 mm (18") above slab rebar and bend back over rebar so as to provide a minimum of 450 mm (18") of support in slab. Do not stress rod when bending.

2.3 HANGER RODS

.1 Provide steel hanger rods, threaded both ends, threaded one end, or continuous threaded.

2.4 SPRING HANGERS

.1 Springs: alloy steel to ASTM A125, shot peened, magnetic particle inspected, with +/- 5% spring rate tolerance, tested for free height, spring rate and loaded height.

.2 Load adjustability: 15% minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities. Total travel to be actual travel + /- 20%. Difference between total travel and actual travel 25 mm minimum.

.3 Vertical movement: 13 mm minimum, 50 mm maximum, use single spring pre-compressed variable spring hangers.

.4 Vertical movement greater than 50 mm: use double spring pre-compressed variable spring hanger with 2 springs in series in single casing.

2.5 DUCT HANGERS AND SUPPORTS

.1 Conform to SMACNA manuals.

2.6 FLASHING

.1 Steel Flashing: 0.5 mm (26 gauge) galvanized steel.

.2 Lead Flashing: 24.4 kg/m² (5 lb/ft$^{2)}$ sheet lead for waterproofing, 4.88 kg/m² (1 lb/ft$^{2)}$ sheet lead for soundproofing.

.3 Safes: 24.4 kg/m² (5 lb/ft^2) sheet lead or 0.5 mm (26 gauge) neoprene.

.4 Caps: Steel, 0.8 mm (22 gauge) minimum, 1.6 mm (16 gauge) at fire resistance structures.

2.7 SLEEVES

.1 Pipes through Floors: Form with steel pipe or approved PVC sleeves.

.2 Pipes through Beams, Walls, Fire Proofing, Footings, Potentially Wet Floor: Form with steel pipe.

.3 Ducts: Form with galvanized steel.

.4 Size large enough to allow for movement due to expansion and to provide for continuous insulation.

2.8 SEALS

.1 Provide modular mechanical type seals between pipes and sleeves where passing through perimeter walls below grade (basement). These to consist of interlocking synthetic rubber links shaped to continuously fill the annular space between the pipe and sleeve when linking bolts are tightened in sequence. Equal to "Link-seal" by Thunderline.

2.9 ACCESS DOORS

.1 Steel frame access panel with stainless steel piano-type hinge, channel reinforced steel door panel, three "Symmons" fasteners per door. Door panel recessed to receive ceiling or wall material to give finished appearance showing only hinge and fasteners. Provide acoustic gasket between door panel perimeter and steel frame. Rated access doors shall be ULC-listed.

Part 3 Execution

3.1 INSERTS

.1 Use inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams wherever practicable.

.2 Set inserts in position in advance of concrete Work. Provide reinforcement rod in concrete for inserts carrying pipe over 100 mm (4”) or ducts over 1500 mm (60”) wide.

.3 Where concrete slabs form finished ceiling, finish inserts flush with slab surface.

.4 Where inserts are omitted, drill through concrete slab from below and provide rod with recessed 100 mm (4”) minimum square steel plate and nut above slab.

3.2 PIPE HANGERS AND SUPPORTS

.1 Support horizontal steel and copper piping as follows:

Nominal Pipe Size mm (in)	Distance Between Supports mm (in)		Hanger Rod Diameter mm (in)
	Steel	Copper	
15 (½”) to 20 (¾”)	1800 (72”)	1500 (60”)	10 (3/8”)
25 (1”) to 40 (1½”)	2100 (84”)	1800 (72”)	10 (3/8”)

50 (2”) to 65 (2½”)	3000 (120”) 2400 (96”)	10 (3/8”)
75 (3”) to 100 (4”)	3600 (144”) 3000 (120”)	16 (½”)
150 (6”) to 300 (12”)	4200 (168”) 4000 (160”)	22 (¾”)
350 (14”) to 450 (18”)	6000 (240”)	25 (1”)

.2 Install hangers to provide minimum 15 mm (½”) clear space between finished covering and adjacent Work.

.3 Use oversize hangers to accommodate pipe insulation thickness. For pipes up to 50 mm (2”) use high density rigid pipe insulation at hanger location, with an insulation protection shield. For pipes 65 mm (2½”) and over use insulation protection saddle.

.4 Place a hanger within 300 mm (12”) of each horizontal elbow.

.5 Use hangers which are vertically adjustable 40 mm (1½”) minimum after piping is erected.

.6 Support cast iron horizontal drainage pipe near each hub and on each side of gasket and clamp joints, with 1500 mm (60”) maximum spacing between hangers.

.7 Support vertical piping at every other floor. Support vertical soil pipe at each floor at hub.

.8 Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.

.9 Where practical, support riser piping independently of connected horizontal piping.

3.3 DUCT HANGERS AND SUPPORTS

.1 Support duct Work in accordance with SMACNA, and as a minimum as follows.

3.4 LOW PRESSURE DUCT HANGERS AND SUPPORTS

.1 Hanger Minimum Sizes:

Up to 750 mm (30”) wide: 25 mm (1”) x 1.6 mm (16 gauge) at 3.0 m (10’-0”) spacing;

775 mm (31”) to 1200 mm (48”) wide: 40 mm (1½”) x 1.6 mm (16 gauge) at 3.0 m (10’-0”) spacing;

Over 1200 mm (48”) wide: 40 mm (1½”) x 1.6 mm (16 gauge) at 3.4 m (11’-0”) spacing.

.2 Horizontal Duct on Wall Supports Minimum Sizes:

Up to 450 mm (18”) wide: 40 mm (1½”) x 1.6 mm (16 gauge) or 25 mm (1”) x 3 mm (12 gauge) at 2.4 m (8’-0”) spacing;

475 mm (19”) to 1000 mm (40”) wide: 40 mm (1½”) x 40 mm (1½”) x 3 mm (12 gauge) at 1.2 m (4’-0”) spacing.

.3 Vertical Duct on Wall Supports Minimum Sizes:

At 3.6 mm (10 gauge) spacing;

Up to 600 mm (24") wide: 40 mm (1½") x 1.6 mm (16 gauge);

625 mm (25") to 900 mm (36") wide: 25 mm (1") x 25 mm (1") x 3 mm (12 gauge);

925 mm (37") to 1200 mm (48") wide: 30 mm (1¼") x 30 mm (1¼") x 3 mm (12 gauge).

.4 Vertical Duct Floor Supports Minimum Sizes:

Riveted or screwed to duct;

Up to 1500 mm (60") wide: 40 mm (1½") x 40 mm (1½") x 3 mm (12 gauge);

Over 1500 mm (60") wide: 50 mm (2") x 50 mm (2") x 3 mm (12 gauge).

3.5 EQUIPMENT BASES AND SUPPORTS

.1 Provide reinforced concrete housekeeping bases poured directly on structural floor slab 100 mm (4") thick minimum, extended 100 mm (4") minimum beyond machinery bedplates for equipment. Provide templates, anchor bolts and accessories required for mounting and anchoring equipment.

.2 Construct supports of structural steel members or steel pipe and fittings. Brace and fasten with flanges bolted to structure.

.3 Provide rigid anchors for ducts and pipes immediately after vibration isolation connections to equipment unless spring hangers are specified.

3.6 PRIMING

.1 Prime coat exposed steel hangers and supports.

3.7 FLASHING

.1 Flash and counterflash where mechanical equipment passes through weather or waterproofed walls, floors and roofs.

.2 Provide curbs for mechanical roof installations 300 mm (12") minimum high. Flash and counterflash with galvanized steel, soldered and made waterproof.

.3 Provide lead acoustic flashing around duct and pipes passing from equipment rooms, installed according to manufacturer's data for sound control.

3.8 SLEEVES

.1 Set sleeves in position in advance of concrete Work. Provide suitable reinforcing around sleeve.

.2 Extend sleeves through potentially wet floors 25 mm (1”) above finished floor level. Caulk sleeves full depth and provide floor plate.

.3 Piping and duct work passing through floor, ceiling or wall, close off space between duct and sleeve with non-combustible insulation. Caulk both sides.

.4 Piping passing through perimeter walls below grade, mechanical room floor,roof or wall, close off space between pipe and sleeve with synthetic rubber compound mechanical type seals.

.5 Sleeves provided through walls or floors where liquids could potentially pass from one side to the other, provide sleeves with a 25 mm (1”) 'flange' welded to the external face of the sleeve at the mid point of the thickness of the structure to provide a water stop.

.6 Install chrome plated escutcheons where piping passes through finished surfaces.

3.9 ACCESS DOORS

.1 Provide access doors for maintenance or adjustment purposes for all mechanical system components including:

.1 Valves
.2 Volume and splitter dampers
.3 Fire Dampers
.4 Coils and terminal units
.5 Control components

.2 Mark removable ceiling tiles used for access with color coded pins. See Painting and Identification.

.3 Sizes to be 600 mm (24”) x 600 mm (24”) minimum.

.4 Provide ULC-listed fire rated access doors installed in rated walls and ceilings.

.5 Access doors will be provided under Section 23 05 29, but installed by the trade governing the surface in which they are to be installed.

Part 1 General

1.1 SCOPE

.1 Supply all labour, materials, and equipment required and necessary to isolate and restrain the equipment as indicated on the drawings and specified herein and guarantee the function of the materials and equipment supplied.

.2 Install 300 mm (12”) long flex connection on all duct work connected to isolated equipment.

1.2 QUALIFICATIONS

.1 All vibration isolators and bases shall be supplied by an approved supplier with the exception of isolators which are factory installed and are standard equipment with the machinery.

.2 Provide shop and placement drawings for all vibration isolation elements for review, before materials are ordered. The drawings shall bear the stamp and signature of the responsible supplier's technical representative.

.3 The Work shall be carried out in accordance with the specification and, where applicable, in accordance with the manufacturer's instructions and only by workmen experienced in this type of Work.

1.3 INSPECTION

.1 A qualified representative of the isolator manufacturer shall inspect the isolated equipment after installation and submit a concise report stating any deficiencies in the installation.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1 Vibro Acoustic, Vibron, IAC, Mason, Korfund, Vibro Acoustics Western.

2.2 ISOLATORS

.1 Spring isolators located out of doors or in humid areas shall have Rustoleum Painted housing and neoprene coated springs, unless otherwise indicated on drawings.

.2 Isolation mounts for equipment with operating weights substantially different from the installed weights, such as chillers, or boilers, shall have adjustable limit stops.

2.3 OPEN SPRING ISOLATORS

.1 Springs shall be "Iso-Stiff" having equal stiffness in the horizontal and vertical planes with a working deflection between 0.3 and 0.6 of solid deflection.

.2 Spring mounts shall be complete with levelling devices, minimum 6 mm (¼") thick neoprene sound pads, and zinc chromate plated hardware.

.3 Sound pads shall be sized for a minimum deflection of 1.2 mm (0.05") and shall meet the requirements for neoprene isolators.

2.4 CLOSED SPRING ISOLATORS

.1 Compression springs shall be used both for hangers and floor mount isolators.

.2 Springs shall be stable under operating conditions.

.3 Housings shall incorporate a minimum 6 mm (¼")thick sound pad sized for a minimum static deflection of 1.2 mm (18 gauge) meeting the requirements for neoprene isolators.

.4 Floor mount units shall incorporate neoprene side stabilizers with a minimum 6 mm (¼") clearance.

2.5 NEOPRENE ISOLATORS

.1 All neoprene isolators shall be tested to ASTM specifications.

.2 Where a ribbed pad is used, the height of the ribs shall not exceed 0.7 times the width of the rib. A steel layer shall be used to distribute the load in a multi-layered unit.

.3 Neoprene pads or elements shall be selected at the manufacturer's optimum recommended loading and shall not be loaded beyond the limit specified in the neoprene manufacturer's literature.

2.6 INERTIA BASES

.1 Concrete inertia bases shall be a minimum of 1.5 times the weight of the isolation equipment and shall be constructed using a channel iron perimeter and adequate reinforcing. The concrete shall be rated at 20 mPa (2900 psi). Design shall be by the isolation suppliers.

.2 Concrete inertia bases shall meet the requirements of the isolation supplier's shop drawings.

.3 Structural steel bases shall be sufficiently rigid to prevent misalignment or undue stress on the machine, and to transmit design loads to the isolators.

2.7 SPRING HANGERS

.1 Hangers capable of a 10° misalignment shall be provided unless otherwise specified.

Part 3 Execution

3.1 APPLICATION

.1 Provide vibration isolation for mechanical motor driven equipment throughout, unless specifically noted otherwise.

.2 Set steel bases for 25 mm (1") clearance between housekeeping pad and base. Set concrete inertia bases for 50 mm (2") clearance. Adjust equipment level.

.3 Deflections 12 mm (½") and over shall use steel spring isolators.

.4 Deflections 5 mm (¼") and under shall use neoprene isolators.

.5 Horizontal limit springs shall be provided on fans operating in excess of 1.5 kPa (6" WG) static pressure, except vertical discharge fans, and on hanger supported, horizontally mounted axial fans where thrust due to static pressure exceeds 300 N.

.6 All equipment mounted on vibration isolators shall have a minimum clearance of 50 mm (2") to other structures, piping, equipment, etc. All isolators shall be adjusted to make equipment level.

.7 Prior to making piping connections to equipment with operating weights substantially different from installed weights, the equipment shall be blocked up with temporary shims to the final heights. When full load is applied, the isolators shall be adjusted to take up the load just enough to allow shim removal.

.8 Adjustable, horizontal stabilizers on close spring isolators shall be adjusted so that the side stabilizers are clear under normal operating conditions.

.9 All piping connections to isolated equipment shall be supported resiliently for the following distances or to the nearest flexible pipe connector:

Pipe Size	Distance, m (ft)
15 - 40 mm (½" - 1½")	3.0 (10'-0")
50 - 65 mm (2" - 2½")	4.5 (15'-0")
75 - 100 mm (3" - 4")	7.0 (23'-0")
125 - 200 mm (5" - 8")	9.0 (30'-0")
225 - 275 mm (9" - 11")	13.5 (44'-0")
300 - 350 mm (12" - 14")	15.0 (50'-0")

The three closest hangers to the vibration source shall be selected for the lesser of a 25 mm (1") static deflection or the static deflection of the isolated equipment. The remaining isolators shall be selected for the lesser of the 25 mm (2") static deflection or 1/2 the static deflection of the isolated equipment.

.10 Spring hangers shall be installed without binding.

.11 Adjust isolators as required and ensure springs are not compressed.

.12 Provide neoprene side snubbers or retaining springs where side torque or thrust may develop.

.13 Where movement limiting restraints are provided, they shall be set in a position with minimum 6 mm (¼") air gap. Restraints, isolator equipment and attachment points shall be designed to withstand the impact of the isolated equipment subjected to an acceleration not exceeding 3 g (0.006615 lb) without permanent distortion or damage.

.14 Wiring connections to isolated equipment shall be flexible.

3.2 PERFORMANCE

.1 Install inertia bases of type and thickness as indicated on Isolation Schedule.

.2 Install isolators of type and deflection as indicated on the Isolation Schedule or according to the following table, whichever provides the greater deflection.

The required static deflection of isolators for equipment exceeding 0.35 Kw (0.5 HP) is indicated below. Spring isolators shall be "open spring". Closed spring isolators shall only be used where specified.

Machine Speed r/min	Slab on Ground Under 15 kW (20 HP)	Structural Slab Over 15 kW (20 HP)	Normal	Critical
Under 400	Special*	Special*	Special*	Special*
400 - 600	25 mm (1")	50 mm (2")	90 mm (4")	Special*
600 - 800	12 mm (½")	25 mm (1")	50 mm (2")	90 mm (4")
800 - 1100	5 mm (¼")	12 mm (½")	25 mm (1")	50 mm (2")
1100 - 1500	3 mm (1/8")	4 mm (3/16")	5 mm (¼")	12 mm (½")

*"Special" indicates as directed by the acoustical consultant.

Part 1 General

1.1 RELATED SECTIONS

.1 Section 01 33 00 - Submittal Procedures

.2 Section 09 91 00 - Painting

1.2 REFERENCES

.1 Canadian Gas Association (CGA)

.1 CSA/CGA B149.1-[00], Natural Gas and Propane Installation Code.

.2 Canadian General Standards Board (CGSB)

.1 CAN/CGSB-1.60-[97], Interior Alkyd Gloss Enamel.

.2 CAN/CGSB-24.3-[92], Identification of Piping Systems.

1.3 PRODUCT DATA

.1 Submit product data in accordance with Section 01 33 00 - Submittal Procedures.

.2 Product data to include paint colour chips, other products specified in this section.

1.4 SAMPLES

.1 Submit samples in accordance with Section 01 33 00 - Submittal Procedures.

1.5 WASTE MANAGEMENT AND DISPOSAL

.1 Separate and recycle waste materials in accordance with Section 01 74 19 - Construction/Demolition Waste Management And Disposal.

.2 Dispose of unused paint material at official hazardous material collections Site approved by Contract Administrator.

.3 Do not dispose of unused paint material into sewer system, into streams, lakes, onto ground or in other locations where it will pose health or environmental hazard.

Part 2 Products

2.1 MANUFACTURER'S EQUIPMENT NAMEPLATES

.1 Metal or plastic laminate nameplate mechanically fastened to each piece of equipment by manufacturer.

.2 Lettering and numbers to be raised or recessed.

.3 Information to include, as appropriate:

.1 Equipment: Manufacturer's name, model, size, serial number, capacity.

.2 Motor: voltage, Hz, phase, power factor, duty, frame size.

2.2 SYSTEM NAMEPLATES

.1 Colours:

.1 Hazardous: red letters, white background.

.2 Elsewhere: black letters, white background (except where required otherwise by applicable codes).

.2 Construction:

.1 3 mm thick [laminated plastic] [or] [white anodized aluminum], matte finish, with square corners, letters accurately aligned and machine engraved into core.

.3 Sizes:

.1 Conform to following table:

Size # mm	Sizes (mm)	No. of Lines	Height of Letters (mm)
1	10 x 50	1	3
2	13 x 75	1	5
3	13 x 75	2	3
4	20 x 100	1	8
5	20 x 100	2	5
6	20 x 200	1	8
7	25 x 125	1	12
8	25 x 125	2	8
9	35 x 200	1	20

.2 Use maximum of 25 letters/numbers per line.

.

.4 Locations:

.1 Terminal cabinets, control panels: Use size # [5].

.2 Equipment in Mechanical Rooms: Use size # [9].

.5 Identification for PWGSC Preventive Maintenance Support System (PMSS):

.1 Use arrangement of Main identifier, Source identifier, Destination identifier.

.2 Equipment in Mechanical Room:

.1 Main identifier: Size #9.

.2 Source and Destination identifiers: Size #6.

.3 Terminal cabinets, control panels: Size #5.

.3 Equipment elsewhere: Sizes as appropriate.

2.3 PIPING SYSTEMS GOVERNED BY CODES

.1 Identification:

.1 Natural gas: to CSA/CGA B149.1

2.4 IDENTIFICATION OF PIPING SYSTEMS

.1 Identify contents by background colour marking, pictogram (as necessary), legend; direction of flow by arrows. To CAN/CGSB 24.3 except where specified otherwise.

.2 Pictograms:

.1 Where required, to Workplace Hazardous Materials Information System (WHMIS) regulations.

.3 Legend:

.1 Block capitals to sizes and colours listed in CAN/CGSB 24.3.

.4 Arrows showing direction of flow:

.1 Outside diameter of pipe or insulation less than 75 mm: 100 mm long x 50 mm high.

.2 Outside diameter of pipe or insulation 75 mm and greater: 150 mm long x 50 mm high.

.3 Use double-headed arrows where flow is reversible.

.5 Extent of background colour marking:

.1 To full circumference of pipe or insulation.

.2 Length to accommodate pictogram, full length of legend and arrows.

.6 Materials for background colour marking, legend, arrows:

.1 Pipes and tubing 20 mm and smaller: Waterproof and heat-resistant pressure sensitive plastic marker tags.

.2 All other pipes: Pressure sensitive [plastic-coated cloth] [vinyl] with protective overcoating, waterproof contact adhesive undercoating, suitable for ambient of 100%RH and continuous operating temperature of 150^{o}C and intermittent temperature of 200^{o}C.

.7 Colours and Legends:

.1 Where not listed, obtain direction from Contract Administrator.

.2 Colours for legends, arrows: To following table:

Background colour:	Legend, arrows:
Yellow	BLACK
Green	WHITE
Red	WHITE

.3 Background colour marking and legends for piping systems:

Contents	Background colour marking	Legend
City water	Green	CITY WATER
Condenser water supply	Green	COND. WTR. SUPPLY
Condenser water return	Green	COND. WTR. RETURN
Chilled water supply	Green	CH. WTR. SUPPLY
Chilled water return	Green	CH. WTR. RETURN
Hot water heating supply	Yellow	HEATING SUPPLY
Hot water heating return	Yellow	HEATING RETURN
Make-up water	Yellow	MAKE-UP WTR
Boiler feed water	Yellow	BLR. FEED WTR
Safety valve vent	Yellow	STEAM VENT
Drinking water return	Green	CH. DRINK WTR. CIRC
Domestic hot water supply	Green	DOM. HW SUPPLY
Dom. HWS recirculation	Green	DOM. HW CIRC
Domestic cold water supply	Green	DOM. CWS
Waste water	Green	WASTE WATER
Storm water	Green	STORM
Sanitary	Green	SAN
Plumbing vent	Green	SAN. VENT

Contents	Background colour marking	Legend
Refrigeration suction	Yellow	REF. SUCTION
Refrigeration liquid	Yellow	REF. LIQUID
Natural gas	to Codes	
Gas regulator vents	to Codes	
Compressed air (<700kPa)	Green	COMP. AIR [___] kPa
Compressed air (>700kPa)	Yellow	COMP. AIR [___] kPa
Vacuum	Green	VACUUM
Fire protection water	Red	FIRE PROT. WTR
Sprinklers	Red	SPRINKLERS
Carbon dioxide	Red	CO2

2.5 IDENTIFICATION DUCTWORK SYSTEMS

.1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.

.2 Colours: Black, or co-ordinated with base colour to ensure strong contrast.

2.6 VALVES, CONTROLLERS

.1 Tags with 12 mm stamped identification data filled with black paint.

.2 Include flow diagrams for each system, of approved size, showing charts and schedules with identification of each tagged item, valve type, service, function, normal position, location of tagged item.

2.7 CONTROLS COMPONENTS IDENTIFICATION

.1 Identify all systems, equipment, components, controls, sensors with system nameplates specified in this section.

.2 Inscriptions to include function and (where appropriate) fail-safe position.

Part 3 Execution

3.1 TIMING

.1 Provide identification only after all painting specified Section [09 91 23 - Interior Painting] has been completed.

3.2 INSTALLATION

.1 Perform Work in accordance with CAN/CGSB-24.3 except as specified otherwise.

.2 Provide CSA registration plates as required by respective agency.

3.3 NAMEPLATES

.1 Locations:

.1 In conspicuous location to facilitate easy reading and identification from operating floor.

.2 Standoffs:

.1 Provide for nameplates on hot and/or insulated surfaces.

.3 Protection

.1 Do not paint, insulate or cover in any way.

3.4 LOCATION OF IDENTIFICATION ON PIPING AND DUCTWORK SYSTEMS

.1 On long straight runs in open areas in boiler rooms, equipment rooms, galleries, tunnels: At not more than 17 m intervals and more frequently if required to ensure that at least one is visible from any one viewpoint in operating areas and walking aisles.

.2 Adjacent to each change in direction.

.3 At least once in each small room through which piping or ductwork passes.

.4 On both sides of visual obstruction or where run is difficult to follow.

.5 On both sides of separations such as walls, floors, partitions.

.6 Where system is installed in pipe chases, ceiling spaces, galleries, confined spaces, at entry and exit points, and at access openings.

.7 At beginning and end points of each run and at each piece of equipment in run.

.8 At point immediately upstream of major manually operated or automatically controlled valves, dampers, etc. Where this is not possible, place identification as close as possible, preferably on upstream side.

.9 Identification to be easily and accurately readable from usual operating areas and from access points.

.1 Position of identification to be approximately at right angles to most convenient line of sight, considering operating positions, lighting conditions, risk of physical damage or injury and reduced visibility over time due to dust and dirt.

3.5 VALVES, CONTROLLERS

.1 Valves and operating controllers, except at plumbing fixtures, radiation, or where in plain sight of equipment they serve: Secure tags with non-ferrous chains or closed "S" hooks.

.2 Install one copy of flow diagrams, valve schedules mounted in frame behind non-glare glass where directed by Contract Administrator . Provide one copy (reduced in size if required) in each operating and maintenance manual.

.3 Number valves in each system consecutively.

END OF SECTION

Part 1 General

1.1 SCOPE

.1 Prepare the facility for balancing.

1.2 RELATED REQUIREMENTS

.1	Commissioning	Section 01 91 13

1.3 RELATED WORK SPECIFIED IN OTHER SECTIONS

.1	Documentation for HVAC Systems	Section 23 05 05
.2	Testing, Adjusting and Balancing for HVAC Systems	Section 23 05 93
.3	Commissioning of HVAC Systems	Section 23 08 00

Part 2 Products

Not Applicable.

Part 3 Execution

3.1 INSTALLATION

.1 Bring the Work to an operating state and ready for balancing, including:

.1 Clean equipment and ductwork.

.2 Install air terminal devices.

.3 Provide temporary filters in air handling equipment and carry out a rough air balance to ensure all equipment performs required function.

.4 Replace filters with specified filters prior to final balancing.

.5 Verify lubrication of equipment.

.6 Install permanent instrumentation.

.7 Complete the "start-up" of equipment.

.8 Review packing and seals on all pumps and valves.

.9 Check rotation and alignment of rotating equipment and tension of belted drives.

.10 Set control points of automatic apparatus, check-out sequence of operation.

.11 Make available control diagrams and sequence of operation.

.12 Clean Work, remove temporary tags, stickers, and coverings.

.13 Make available one (1) copy of Maintenance Manuals especially for use in balancing.

.14 Provide Balancing Agency a complete set of mechanical drawings and specifications.

.2 Cooperate with the Balancing Agency as follows:

.1 Make corrections as required by Balancing Agency.

.2 Allow Balancing Agency free access to Site during construction phase. Inform Balancing Agency of any major changes made to systems during construction and provide a complete set of record drawings for their use.

.3 Provide and install any additional balancing valves, dampers, and other materials requested by the balancing agency and/or necessary to properly adjust or correct the systems to design flows.

.4 Provide and install revised pulleys and sheaves for rotating equipment and shave pump impellers, as required to properly balance the systems to design flows. Obtain requirements from balancing agency.

.5 Operate automatic control system and verify set points during Balancing.

Part 1 General

1.1 SCOPE

.1 Balance, adjust, and test air and liquid systems and equipment and submit reports using identical units to those shown on Contract documents.

1.2 QUALITY ASSURANCE

.1 Work specified in this section shall be performed by an Independent Agency specializing in this type of Work.

.2 Balancing (of both air and liquid systems) shall be performed by the same agency.

.3 Balancing procedures shall be in accordance with SMACNA and ASHRAE Standards.

.4 During the one year warranty period, the City may request re-check or re-setting of outlets or fans as listed in test report. Provide technicians and equipment required during visits for seasonal adjustments.

1.3 APPROVED AGENCIES

.1 AABC, AMS.

.2 Or alternatively, Contractor to submit proposed agency for Contract Administrator and The City approval.

1.4 RELATED REQUIREMENTS

.1 Commissioning for HVAC Section 23 08 00

1.5 RELATED WORK SPECIFIED IN OTHER SECTIONS

.1 Documentation for HVAC Systems Section 23 05 05

1.6 SITE VISITS

.1 After each Site visit, a written report shall be submitted to the Contractor and Contract Administrator. Site visits shall commence after the start of air and liquid distribution Work and be spread over the construction period to the start of the balancing Work.

.2 A review of the installation and access to all valves, dampers, and equipment shall be made at the specified Site visits and any additional dampers or valves required for proper balancing shall be forwarded in writing to be reviewed by the Contract Administrator.

.3 Allow days on Site to adjust systems for seasonal changes during warranty. Coordinate time of visits with the City. Submit reports to Contract Administrator.

.4 Begin balancing after equipment start-up and testing and after systems have been completed and are in full working order. Place systems and equipment into full operation and continue operation during each working day of balancing.

1.7 BALANCING AGENDA

.1 General: Submit balancing agenda to the Contract Administrator and commissioning Contractor for review at least sixty (30) **d**ays prior to the start of balancing Work. Start balancing Work only after agenda has been approved. Include descriptive data, procedure data, and sample forms in agenda.

.2 Descriptive Data: General description of each system including associated equipment and different operation cycles, listing of flow and terminal measurements to be performed and selection points for proposed sound measurements.

.3 Procedure Data: Procedures for converting test measurements to establish compliance with requirements, specify type of instrument to be used, method of instrument application (by sketch) and correction factors.

.4 Sample Forms: Form showing application of procedures to typical systems.

.5 At the completion of balancing the first major air system or pre-arranged milestone, the balancing agent shall notify the Contract Administrator to re-visit the Site to evaluate Work completed to this time. Provide the Contract Administrator with **10** days written notice, prior to request for Site visit.

1.8 BALANCE REPORT

.1 Submit (2) copies of rough balancing reports to the Contract Administrator for review, prior to on-Site verification and acceptance of Project.

.2 Provide four (4) copies of final reports to Contractor for inserting in The City's's Operating and Maintenance Manuals as described in Section 23 05 05, Documentation for HVAC Systems.

.3 Include types, serial number, and dates of calibration of instruments in the reports.

1.9 SYSTEM DATA

.1 Air Handling Equipment

Design Data:

Total air flow rate;
Fan total static pressure;
System static pressure;
Motor Kw (HP), r/min, amps, Volts, Phase;
Outside air flow rate L/s (cfm);
Fan r/min;
Fan/kW (HP);

Inlet and outlet, dry and wet bulb temperatures.

Installation Data:

Manufacturer and model;
Size;
Arrangement discharge and class;
Motor type, kW (HP), r/min, voltage, phase, cycles, and load amperage;
Location and local identification data.

Recorded Data:

Supply Air Fan
- Fan @ 100% Outside Air
  Air flow rate;
  Fan total static pressure;
  System static pressure;
- Fan @ Full Return/Min O/A
  Air flow rate;
  Fan total static pressure;
  System static pressure;

Exhaust Air Fan
- Fan @ 100% Exhaust Air
  Air flow rate;
  Fan total static pressure;
  System static pressure;
- Fan @ Full Return
  Air flow rate;
  Fan total static pressure;
  System static pressure;

Fan r/min;
For Axial Fans, note blade pitch angle
Motor operating amperage;
Inlet and outlet, dry and wet bulb temperatures.

.2 Duct Air Quantities - All mains supplying more than 10% of Volume, outside air and exhaust (maximum and minimum) major return air openings back to duct shafts.

Duct sizes;
Number of pressure readings;
Sum of velocity measurements;
Average velocity;
Duct recorded air flow rate;
Duct design air flow rate.

.3 Air Inlet and Outlets:

Outlet identification location and designation;
Manufacturers catalogue identification and type;
*Application factors;

Design and recorded velocities;
Design and recorded air flow rates;
Deflector vane or diffuser cone settings.

* (Refer to 3.1.3 for supporting information)

.4 Pumps

Design Data

Fluid flow rate;
Total Head;
r/min;
kW (HP), r/min, amps, volts, phase.

Installation Data

Manufacturer and model;
Size;
Type drive;
Motor type, kW (HP), r/m, voltage, phase, and full load amperage.

Recorded Data:

Discharge and suction pressures with secondary systems on both bypass and full circulation (full flow and no flow);
Operating head;
Operating water flow rate (from pump curves if metering not provided);
Motor operating amps (full flow and no flow);
r/min.

.5 Expansion Tank

Design Data:

Size;
Capacity;
Pressure rating;
Installation Data:
Manufacturer, size, capacity;
Pressure reducing valve setting;
Pressure relief valve setting.

.6 Heating Equipment (Boilers, Unit heaters, Reheats, In-floor heating, etc.)

Design Data:

Heat transfer rate;
Fluid flow rate;
Entering and leaving fluid temperatures;

Fluid pressure drop.

Installation Data:

Manufacturer, Model, Type;
Entering and leaving fluid temperatures;
Capacity;
Pressure drops;
Flow rates.

Recorded Data:

Element type and identification (location and designation);
Entering and leaving fluid temperature (for varying outdoor temperatures);
Fluid pressure drop;
Fluid flow rate;
Pressure relief valve setting.

.7 Energy Recovery Ventilator

Design Data:

Air flow rates (heated media, heating media);
exhaust and supply inlet and outlet temperatures.

Installation Data:

Manufacturer, model, type;
Air flow rates;
Inlet and outlet temperatures;

Recorded Data

exhaust and supply inlet and outlet temperatures.
Entering and leaving temperatures (for varying outdoor temperatures) and pressures;

Part 2 Products

2.1 INSTRUMENTS

.1 Provide calibration histories for each instrument. Recalibration or use of other instruments may be requested when accuracy of readings is questionable.

Part 3 Execution

3.1 GENERAL PROCEDURE

.1 Permanently mark, by stick-on labels and/or fluorescent paint, settings on valves, splitters, dampers, and other adjustment devices.

.2 Subsequent to correctional Work, take measurements to verify balance has not been disrupted or that any such disruption has been rectified.

.3 Where vane anemometer is used to measure supply, return or exhaust air grilles, AK factors shall be determined as follows:

.1 Determine and tabulate similar sized grilles being balanced for AK schedule.

.2 Traverse all ducts serving grilles (outlined in AK schedule) to verify AK factors.

.3 AK factor from schedule, must be approved by Contract Administrator during initial review with balancer on Site. (Balancer shall include written procedure for determination of AK factors).

.4 No flow hoods are to be used for measurement of exhaust or return air grilles.

.4 Balancing shall be performed to the following accuracies:

.1	Air - terminal outlets	±10% (outlets less than 200 L/s [425 cfm])
.2	Air - terminal outlets	±5% (outlets greater than 200 L/s[425 cfm])
.3	Air - central equipment	±5%
.4	Hydronic - terminal outlets	±10%
.5	Hydronic - pumps and central	±5%

.5 Where axial fans require blade pitch changes, this shall be the responsibility of the balancing Contractor.

.6 Where pump impellers require shaving, this shall be the responsibility of the Mechanical Subcontractor. All adjustments shall be by qualified millwright. All changes shall be documented and included as part of the balancing report.

3.2 AIR SYSTEM PROCEDURE

.1 Perform balancing, adjusting, and testing with building doors and windows in their normal operation position.

.2 The following procedure shall be adopted for central systems:

.1 Ensure dampers or volume control devices are in fully open position.
.2 Balance central apparatus to ±5% air flow.
.3 Balance branches and mains in accordance with 3.1.4.
.4 Recheck central apparatus.
.5 Balance all terminal air outlets in accordance with 3.1.4.

.6 Re-balance central apparatus to ±5%.
.7 Recheck all air outlets.
.8 Perform acoustical measurements.

.3 When balancing air outlets:

.1 Rough balance furthest outlets and then balance sequentially back to source.
.2 Fine balance furthest outlet back to source.

.4 Take static pressure readings and air supply temperature readings at 10 points on each AHU air system.

.5 Make air quantity measurements in ducts by "Pitot Tube" traverse of entire cross sectional area. Take minimum of 16 for rectangular ducts, and 10 on each vertical and horizontal axis for round ducts, traverse readings. If readings are inconsistent across duct, try to obtain straight run of six (6) diameters widths upstream and re-do traverse.

.6 Use volume control devices to regulate air quantities only to extent that adjustments do not create objectionable air motion or sound levels. Effect volume control only by duct internal devices such as dampers and splitters.

.7 Vary total system air quantities by adjustment of fan speeds. Vary branch air quantities by damper regulation.

.8 Where modulating dampers are provided, take measurements and balance at extreme conditions. (Balance variable volume systems at maximum air flow rate - full cooling, and at minimum air flow rate - full heating).

.9 Verify all terminal unit factory settings for maximum air flow (and minimum if applicable). Adjust terminal unit controller if required. Record adjusted units.

.10 The final balanced condition of each area shall include testing and adjusting of pressure conditions. Test and record building pressurization levels in variable volume systems throughout full range of fan delivery rates, under both heating and cooling conditions. For multi-storey building test pressure conditions at ground, intermediate and upper levels. Front doors, exits, elevator shafts, should be checked for air flow so that exterior conditions do not cause excessive or abnormal pressure conditions. Document abnormal building leakage conditions noted.

.11 Complete balancing to achieve positive building pressure unless otherwise instructed. A positive pressure relative to outside of 10 Pa (0.04”WG) minimum and 20 Pa (0.08”WG) maximum shall be achieved, measured with negligible outside wind velocity.

3.3 FIRE DAMPER/FIRE STOP FLAP VERIFICATION

.1 Visually inspect all fire dampers and fire stop flaps:

.1 Installation is straight.
.2 Wall angles properly installed.
.3 Duct has break away connection.

.4 Fire stopping material where used is properly installed.
.5 Adequate access.
.6 Clearance between sleeve and wall.

.2 Inspect all fire damper blades and tracks prior to test firing. Sheet metal trade to clean all dirty dampers and tracks to satisfaction of balancer.

.3 Manually remove each fusible link to ensure damper blade drops properly, then reset damper. Mark dropped fire damper with black felt marker.

.4 Testing of 10% of the fusible links shall be performed with a suitable heat source capable of generating sufficient heat to detonate fusible link without burning or generating carbon deposits on the blades, frame or adjacent ductwork. Selection of links to be test dropped to be as directed by Contract Administrator. Retesting and resetting shall be witnessed by Contract Administrator.

.5 If fire damper does not close properly, sheet metal trade to repair installation and balancing agency to retest.

.6 All fire damper tests shall be witnessed by two parties, certified by Contractor and endorsed by the testing personnel.

.7 Contact Manitoba Building Code enforcement authorities in writing prior to testing each damper and have authorities witness tests as required.

3.4 BALANCING AND ADJUSTING OF DOMESTIC WATER SYSTEMS

.1 Adjust pressure on main line to 275.8 kPa (40 psi) maximum.

.2 Balance domestic hot water recirculating system piping to ensure flow from all points in the system. Ensure all hot and cold supply shut off valves are fully open.

3.5 BALANCING REPORT

.1 Submit draft copies of rough balancing reports prior to final acceptance of project.

.2 Include types, serial number and dates of calibration of instruments.

.3 Record test data on a sepia made from the latest available revised set of mechanical drawings and submit three (3) copies upon completion of the balancing Contract for inclusion in equipment and maintenance manuals.

.4 Submit with report, fan and pump curves with operating conditions plotted. Submit grille and diffuser shop drawings and diffusion factors.

.5 Report shall be indexed as follows:

Air

Summary

Procedure
Instrumentation
Drawings
Equipment Summary
Fan Sheets
Fan Curves
Fan Profile Data
Static Data
Air Monitoring Station Data
Traverse Data and Schedule
Terminal Unit Summary
Outlet Data Summary and Schematics (per system)
Building Schematic
Building Pressurization Data
Weather Conditions at Time of Test
Diagnostic
Millwright Reports

Liquid

Summary
Procedure
Instrumentation
Drawings
Pump Data
Pump Curves
Flow Stations
Coils
Equipment Data
Element Data Summary and Schematics (per system)
Diagnostic
Millwright Reports

Part 1 General

1.1 SCOPE

.1 Duct thermal insulation.

.2 Duct acoustic insulation.

.3 Adhesives, tie wires, tapes.

.4 Recovery.

.5 All exterior ductwork.

1.2 QUALITY ASSURANCE

.1 Insulation shall be installed by skilled workmen regularly engaged in this type of Work.

.2 Materials shall meet fire and smoke hazard ratings as stated in this section and defined in applicable building codes.

1.3 SUBMITTALS

.1 Submit shop drawings which indicate complete material data, "K" value temperature rating, density, finish, recovery jacket of materials proposed for this project and indicate thickness of material for individual services.

1.4 JOB CONDITIONS

.1 Deliver material to job Site in original non-broken factory packaging, labelled with manufacturer's density and thickness.

.2 Perform Work at ambient and equipment temperatures as recommended by the adhesive manufacturer. Make good separation of joints or cracking of insulation due to thermal movement, poor workmanship, or material defects.

1.5 ALTERNATIVES

.1 Alternative insulations are subject to approval. Alternatives shall provide the same thermal resistance within 5%, at normal conditions as material specified.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1 Owen's Corning/Fiberglas Canada Inc., Knauf Fiberglass, Manson.

2.2 GENERAL

.1 Insulation Material, Recovery Jackets, Vapour Barrier Facings, Tapes and Adhesives: Composite fire and smoke hazard ratings shall not exceed 25 for flame spread and 50 for smoke developed.

.2 Insulating materials and accessories shall withstand service temperatures without smouldering, glowing, smoking or flaming.

.3 Recovery Jackets : Indoor - **[**Canvas: ULC listed 220 g/m^2 (0.044 lbs/ft^2)plain weave cotton fabric with dilute ULC listed fire retardant lagging adhesive.**]**

: Outdoor -**[**0.9 mm (22 gauge) embossed aluminum sheet for breeching.

.4 All insulation materials shall meet Building Code Standards, and packages or containers of such materials shall be appropriately labelled.

2.3 MATERIALS

.1 Exposed Rectangular Ducts: Rigid fibrous glass or mineral fibreboard insulation, "K" value maximum 0.035 W/m. °C at 24°C (0.24 btu in/hr/ft^2 at 75°F). Factory applied reinforced aluminum foil vapour barrier for cold ducts. Hot duct service temperature 20°C (68°F) to 65°C (149°F). Cold ducts service temperature -40°C (-40°F) to 65°C (149°F).

.2 Round Ducts and Concealed Rectangular Ducts: Flexible fibrous glass or mineral fibre insulation, "K" value maximum 0.035 W/m. °C at 24°C (0.24 btu in/hr/ft^2 at 75°F). Factory applied reinforced aluminum foil vapour barrier for cold ducts. Hot duct service temperature 20°C to 65°C (68°F to 149°F). Cold duct service temperature -40°C (-40°F) to 65°C (149°F).

.3 Acoustic Lining: Fibrous glass or mineral fibreboard insulation with "K" value maximum 0.035 W/m. °C, at 24°C (0.24 btu in/hr/ft^2 at 75°F). Absolute roughness of exposed surface not to exceed 0.58 mm (26 gauge), coated to prevent fibre erosion at air velocities up to 25.4 m/s, 24 kg/m^2 (5000 ft/m, 5 lb/ft^2) minimum density for ductwork and plenums. Substrate must not be dark in colour. Service temperature -40°C (-40°F) to 65°C (149°F).

Part 3 Execution

3.1 PREPARATION

.1 Do not install covering before ductwork and equipment has been tested and approved.

.2 Ensure surface is clean and dry prior to installation. Ensure insulation is dry before and during application. Finish with systems at operating conditions, where possible.

3.2 INSTALLATION

.1 Ensure insulation is continuous through floor and wall sleeves etc. Pack around ducts with fireproof self-supporting insulation materials, properly sealed.

.2 Finish insulation neatly at hangers, supports and other protrusions.

.3 Do not insulate ductwork with external thermal insulation where acoustic duct insulation is specified or indicated.

.4 Locate insulation or cover seams in least visible locations. Locate seams on ductwork in ceiling spaces on the underside of the duct.

.5 Provide recovering jackets on exposed insulation throughout, including equipment rooms. Insulation located in crawl spaces, shafts and suspended ceiling spaces is not considered exposed. Make smooth any uneven insulated surface before recovering.

.6 Cover insulation exposed to outdoors with aluminum jacket secured with aluminum bands on 200 mm (8") centres. Longitudinal slip joints, lap circumferential joints 75 mm (3") minimum and seal all joints with compatible waterproof lap cement.

.7 Exposed Rectangular Ducts: Secure rigid insulation with galvanized anchors, or weld pins on 400 mm (16") centres. Secure in place with retaining clips. Seal all insulation joints and breaks with joint tape. Use vapour barrier tape for insulation joints or breaks on cold ducts.

.8 Round Ducts and Concealed Rectangular Ducts: Adhere flexible insulation to ductwork with adhesive applied in 150 mm (6") wide strips on 400 mm (16") centers. Provide annealed tie wire tied at 400 mm (16") centers for securing duct insulation. Butt insulation and seal joints and breaks with lap seal adhesive; cover joints with joint tape. Use vapour barrier tape for cold ducts.

.9 Acoustic Lining: Apply to interior of ducts where shown. Secure to ductwork with adhesive using 50% coverage and anchors or weld pins on 400 mm (16") centers. Secure in place with retaining clips. Cut off excess fastener length and cover with brush coat of mastic over protrusions and all raw edges. Use 25 mm (1") thick insulation unless otherwise noted. Provide vapour barrier located on the warm side for outside air intakes. Bevel corners at joints and butt together. Install acoustic gauze over all cut corners and joints and brush coat with lap seal adhesive.

.10 Where duct velocities exceed 10 m/s (2000 ft/m), cover insulation with 0.8 mm perforated galvanized steel with 24% free area.

.11 Fasten aluminum recovery jacket in place with aluminum banding on 200 mm (8") centres or screws or rivets on 150 mm (6") centres. Longitudinal slip joints and 50 mm (2") lap joints.

3.3 INSULATION INSTALLATION THICKNESS SCHEDULE

	Ducts & Equipment	Insulation Thickness mm (in)	Recovery Jacket
.1	Combustion Air and Relief Duct	50 (2”)	Canvas
.2	Exhaust Ducts within 3 m (10’-0”) of Exterior Walls or Openings.	25 (1”)	Canvas
.3	Outside Air Intake Ducts	50 (2”)	Canvas
.4	Ductwork exposed to outdoors	50 (2”)	Aluminum
.5	Ductwork exposed to outdoors with acoustic lining	50 (2”) (Acoustic)	-
.6	Plenums (Heating Systems)	50 (2”)	-
.7	Plenums (Systems with Cooling Coils)	50 (2”)	-
.8	Supply Ducts (Heating System)	25 (1”)	Canvas
.9	Supply Ducts (Heating / Cooling System)	25 (1”)	Canvas
.10	Supply Ducts Ventilation Systems	25 (1”)	Canvas
.11	Ventilation Equipment Casings	25 (1”)	Canvas
.12	Acoustic Lining (where indicated)	25 (unless indicated otherwise)	-
.13	Acoustic Lining for AHU-1 within Mechanical Room	25 (1”)	-
.14	Domestic hot water breeching (atmospheric burners)	25 (1”)	Aluminum
.15	Ventilation equipment	50 (2”)	Canvas

Part 1 General

1.1 summary

.1 Section Includes:

1. General requirements for Commissioning of HVAC equipment and systems.

.2 Related Sections:

1. Section 23 05 93 Testing, Adjusting and Balancing for HVAC

2. Section 22 08 00 Commissioning of Plumbing

.3 Acronyms:

1. Cx - Commissioning.

2. CxA - Commissioning Agent

1.2 INTENT

.1 All items noted in this document are the responsibility of the Contractor supplying and installing the equipment, unless noted otherwise.

1.3 MANUFACTURER'S SERVICE ON SITE

.1 Arrange and pay for qualified Manufacturer's representatives to supervise starting and testing of the following mechanical equipment and systems (if applicable):

1. Air Handling Units

2. Variable Frequency Drives

3. Heat Recovery

.2 Use manufacturers factory trained personnel where required to maintain manufacturer's warranty.

.3 Maintain documentation of all equipment start-up and commissioning and provide to Commissioning Agent and Mechanical Contract Administrator.

Part 2 Products

NOT APPLICABLE.

Part 3 Execution

3.1 GENERAL

.1 Commission all equipment and systems installed as part of this Contract. Typical required information or actions are listed below for each equipment or system.

.2 Provide check sheets for equipment not listed in this section.

.3 Document the commissioning process by completing the Component Verification Forms, System (functional) Tests and Integrated System Tests.

3.2 AIR HANDLING EQUIPMENT AND SYSTEMS - AIR HANDLING UNITS

1. Check that installation is in accordance with drawings, specifications and Manufacturer's recommendations.

2. Complete Manufacturer's installation and start-up check sheets and include the following:

.1 Air blender and mixing baffles.

.2 Fresh, exhaust and recirculation air motorized dampers, operation and size.

.3 Filters.

.4 Check that fan base vibration isolation and flexible connections to ductwork are properly installed.

.5 Special features, access doors, liners, inlet vanes and labels.

.6 Ensure silencers are installed.

.7 Lubricate bearings on fans as recommended by Manufacturer. Ensure fan wheels rotate in correct direction without binding. Adjust belts to proper alignment and tension.

.8 Vacuum clean air systems.

.9 Ensure temporary filters are installed. NEVER operate system without filters installed.

.10 Ensure all balancing and fire dampers are open and ductwork is complete.

.11 Ensure all coils are in operation. If outside air temperature is less than 2°C, ensure coils are dry or filled with glycol.

.12 On parallel fan systems ensure backdraft dampers are installed.

.13 Ensure electrical connections are complete and system disconnects are within sight of unit.

.14 Ensure controls are operational.

.15 Ensure inlet and discharge duct geometry is correct.

.16 Ensure hose bibs have been installed for washing coils.

3. Start the system in accordance with the Manufacturer's recommendations.

.17 Check for correct static deflection of unit vibration isolators and that start-up and shut down deflection is within resilience limits.

.18 Run for one day and check filters, coils, and humidifier for bypass. Seal as required.

4. Provide performance testing to ensure equipment meets specifications.

.19 Verify operation of the Heat Recovery Unit (if present).

.20 Confirm that unit is performing as per specifications.

.21 Check controls operation and tune operating parameters to optimize air handling unit performance.

.22 Tune system for energy efficient operation

5. Provide maintenance services.

.23 Check that bearings are not overheating.

.24 Replace temporary filters with permanent filters.

.25 Wash heating, cooling and steam injected humidifier coils.

.26 Lubricate bearings.

.27 Check belts for tension and wear.

.28 Ensure that coils can be drained and that the drainage system is functioning properly.

.29 Ensure that all equipment is serviced prior to the City takeover.

.30 Ensure that all equipment is installed so as to provide easy access for maintenance and removal.

3.3 AIR HANDLING EQUIPMENT AND SYSTEMS – FANS

1. Check that installation is in accordance with drawings, specifications and Manufacturer's recommendations.

2. Complete Manufacturer's installation and start-up check sheets and include the following:

.1 Backdraft dampers.

.2 Accessories.

.3 Special features.

.4 Check that fan base vibration isolation and flexible connections to ductwork are properly installed.

.5 Lubricate bearings on fans as recommended by Manufacturer.

.6 Ensure fan wheels rotate in correct direction without binding.

.7 Adjust belts to proper alignment and tension.

.8 Ensure ductwork and fan casing is free of dirt or foreign material.

.9 Ensure electrical connections are complete and disconnect is within sight of fan.

.10 Ensure inlet and discharge duct geometry is correct.

3. Follow Manufacturer's recommendations for starting

.11 Check for correct static deflection of unit vibration isolators, and that start-up and shut down deflection is within resilience limits.

4. Provide performance testing to ensure fan performance meets or exceeds performance outlined in the specifications.

5. Provide maintenance services.

.12 Check that bearings are not over heating.

.13 Lubricate bearings.

.14 Check belts for tension and wear.

.15 Confirm that all equipment is easily accessible for maintenance purposes.

3.4 AIR HANDLING EQUIPMENT AND SYSTEMS – VAV BOXES

1. Check that installation is in accordance with drawings, specifications and Manufacturer's recommendations.

2. Complete Manufacturer's installation and start-up check sheets and include the following:

.1 No physical damage to the unit has occurred.

.2 Unit is free of foreign debris.

.3 All bolts and screws are tight.

.4 All ducting connections are properly installed.

.5 Takeoffs for future installations are provided.

.6 Controls and damper actuators are installed in a neat and tidy manner.

.7 Control's points list and flowcharts are completed.

.8 Equipment is labelled.

.9 Check insulation installation for specified thickness and quality of installation.

.10 Unit is clean and free from debris.

3. Provide performance testing to ensure that dampers perform as per specifications.

4. Ensure that all equipment is installed so as to provide easy access for maintenance and removal.

3.5 AIR HANDLING EQUIPMENT AND SYSTEMS - FORCE FLOW/UNIT HEATERS

1. Check that installation is in accordance with drawings, specifications and Manufacturer's recommendations.

2. Complete Manufacturer's installation and start-up check sheets and include the following:

.1 Piping connections are properly installed.

.2 Vibration isolation and flexible connections on pipes are properly installed.

.3 Ducting connections are properly installed.

.4 Disconnect switches are functional.

.5 Unit is clean and free from debris.

.6 No physical damage to unit has occurred.

.7 All bolts, screws are tight.

.8 All fins have been combed and are not bent.

.9 Takeoffs for future installations are provided.

.10 Provisions for draining system in the event of leakage or additions to the system.

.11 Controls and valves are installed in a neat and tidy manner.

.12 All equipment is installed so as to provide access for maintenance and removal.

.13 Controls points list and flowcharts are completed.

.14 Equipment is labelled.

3. Provide maintenance services.

.15 Adjust thermostat to final setting

.16 Clean unit

.17 Confirm that all equipment is accessible for maintenance and operations

4. Confirm that unit heaters are performing as intended.

3.6 AIR HANDLING EQUIPMENT AND SYSTEMS – DISTRIBUTION

1. Check that installation is in accordance with drawings, specifications and Manufacturer's recommendations.

2. Complete Manufacturer's installation and start-up check sheets.

3. Inspect air systems including ductwork layout, support, and vibration isolation before pressure testing any section of ductwork.

4. Power vacuum all ducts.

5. Pressure test sections of ductwork prior to application of insulation or concealment. Include pressure testing of ductwork on commissioning schedule and notify The City prior to any system pressure tests.

6. Check that insulation is installed as per specifications and is neat and tidy.

7. Check that insulation has not been damaged during construction and note any sections that require repair.

8. Check that all distribution ductwork is labelled.

9. Provide Testing, Adjusting and Balancing for all Air Handling Equipment and Systems by a Certified Independent Agent.

10. Provide performance testing to ensure that air handling equipment and systems perform as per specifications.

11. Provide maintenance services.

.1 Ensure all equipment is serviced prior to take-over.

.2 Ensure all equipment is installed so as to provide easy access for maintenance and removal.

3.7 MECHANICAL EQUIPMENT AND SYSTEMS TESTING, ADJUSTING AND BALANCING

1. Provide Testing, Adjusting and Balancing in accordance with Section 23 05 93.

Part 1 General

1.1 GENERAL

.1 Related Documents

.1 All Work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.

.2 The Work of this Division shall be scheduled, coordinated, and interfaced with the associated Work of other trades. Reference the Division 22, 23 Sections for details.

.3 The Work of this Division shall be as required by the Specifications, Point Schedules and Drawings.

.4 If the BMS Subcontractor believes there are conflicts or missing information in the project documents, the Contractor shall promptly request clarification and instruction from the design team.

1.2 DEFINITIONS

.1 Analog: A continuously variable system or value not having discrete levels. Typically exists within a defined range of limiting values.

.2 Binary: A two-state system where an “ON” condition is represented by one discrete signal level and an “OFF” condition is represented by a second discrete signal level.

.3 Building Management System (BMS): The total integrated system of fully operational and functional elements, including equipment, software, programming, and associated materials, to be provided by this Division BMS Subcontractor and to be interfaced to the associated Work of other related trades.

.4 BMS Subcontractor: The single Contractor to provide the Work of this Division. This Contractor shall be the primary manufacturer, installer, commissioner and ongoing service provider for the BMS Work.

.5 Control Sequence: A BMS pre-programmed arrangement of software algorithms, logical computation, target values and limits as required to attain the defined operational control objectives.

.6 Direct Digital Control: The digital algorithms and pre-defined arrangements included in the BMS software to provide direct closed-loop control for the designated equipment and controlled variables. Inclusive of Proportional, Derivative and Integral control algorithms together with target values, limits, logical functions, arithmetic functions, constant values, timing considerations and the like.

.7 BMS Network: The total digital on-line real-time interconnected configuration of BMS digital processing units, workstations, panels, sub-panels, controllers, devices and associated elements individually known as network nodes. May exist as one or more fully interfaced and integrated sub-networks, LAN, WAN or the like.

.8 Node: A digitally programmable entity existing on the BMS network.

.9 BMS Integration: The complete functional and operational interconnection and interfacing of all BMS Work elements and nodes in compliance with all applicable codes, standards and ordinances so as to provide a single coherent BMS as required by this Division.

.10 Provide: The term "Provide" and its derivatives when used in this Division shall mean to furnish, install in place, connect, calibrate, test, commission, warrant, document and supply the associated required services ready for operation.

.11 PC: IBM-compatible Personal Computer from a recognized major manufacturer

.12 Furnish: The term "Furnish" and its derivatives when used in this Division shall mean supply at the BMS Subcontractor's cost to the designated third party trade Contractor for installation. BMS Subcontractor shall connect furnished items to the BMS, calibrate, test, commission, warrant and document.

.13 Wiring: The term "Wiring" and its derivatives when used in this Division shall mean provide the BMS wiring and terminations.

.14 Install: The term "Install" and its derivatives when used in this Division shall mean receive at the jobsite and mount.

.15 Protocol: The term "protocol" and its derivatives when used in this Division shall mean a defined set of rules and standards governing the on-line exchange of data between BMS network nodes.

.16 Software: The term "software" and its derivatives when used in this Division shall mean all of programmed digital processor software, preprogrammed firmware and project specific digital process programming and database entries and definitions as generally understood in the BMS industry for real-time, on-line, integrated BMS configurations.

.17 The use of words in the singular in these Division documents shall not be considered as limiting when other indications in these documents denote that more than one such item is being referenced.

.18 Headings, paragraph numbers, titles, shading, bolding, underscores, clouds and other symbolic interpretation aids included in the Division documents are for general information only and are to assist in the reading and interpretation of these Documents.

.19 The following abbreviations and acronyms may be used in describing the Work of this Division:

ADC	-	Analog to Digital Converter
AI	-	Analog Input
AN	-	Application Node
ANSI	-	American National Standards Institute

AO	-	Analog Output
ASCII	-	American Standard Code for Information Interchange
ASHRAE		American Society of Heating, Refrigeration and Air Conditioning Engineers
AWG	-	American Wire Gauge
BMS	-	Building Management System
CPU	-	Central Processing Unit
CRT	-	Cathode Ray Tube
DAC	-	Digital to Analog Converter
DDC	-	Direct Digital Control
DI	-	Digital Input
DO	-	Digital Output
EEPROM	-	Electronically Erasable Programmable Read Only Memory
EMI	-	Electromagnetic Interference
FAS	-	Fire Alarm Detection and Annunciation System
GUI	-	Graphical User Interface
HOA	-	Hand-Off-Auto
ID	-	Identification
IEEE	-	Institute of Electrical and Electronics Engineers
I/O	-	Input/Output
LAN	-	Local Area Network
LCD	-	Liquid Crystal Display
LED	-	Light Emitting Diode

MCC	-	Motor Control Center
NC	-	Normally Closed
NIC	-	Not In Contract
NO	-	Normally Open
OWS	-	Operator Workstation
OAT	-	Outdoor Air Temperature
PC	-	Personal Computer
RAM	-	Random Access Memory
RF	-	Radio Frequency
RFI	-	Radio Frequency Interference
RH	-	Relative Humidity
ROM	-	Read Only Memory
RTD	-	Resistance Temperature Device
SPDT	-	Single Pole Double Throw
SPST	-	Single Pole Single Throw
XVGA	-	Extended Video Graphics Adapter
TBA	-	To Be Advised
TCP/IP	-	Transmission Control Protocol/Internet Protocol
TTD	-	Thermistor Temperature Device
UPS	-	Uninterruptible Power Supply
VAC	-	Volts, Alternating Current
VAV	-	Variable Air Volume
VDC	-	Volts, Direct Current
WAN	-	Wide Area Network

1.3 BMS DESCRIPTION

.1 The City of Winnipeg has an existing central monitoring system in place. Where DDC points are identified as centrally monitored points, the controls Contractor shall provide and install required hardware and software to interface to the City's Johnson Controls Metasys EA servers and workstations. These are located at the Central Control Offices, 510 Main Street, Winnipeg, Manitoba.

.2 Controls Contractor to supply all drawings/graphics/sequence of operations in both a hard and soft copy. Drawings and graphics to be able to be read and modified by City of Winnipeg Staff. User interface graphics to be completed using Graphic Generation Tool software. Graphics must use City of Winnipeg graphic templates. Contractor to supply As-Built drawings in an editable format, able to be easily edited by City of Winnipeg Staff.

.3 BACnet shall be used in this new building.

.4 No LON,and No N2 protocols are to be accepted.

.5 The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems. This functionality shall extend into the equipment rooms. Devices residing on the automation network located in equipment rooms and similar shall be fully IT compatible devices that mount and communicate directly on the IT infrastructure in the facility. Contractor shall be responsible for coordination with the City's IT staff to ensure that the BMS will perform in the City's environment without disruption to any of the other activities taking place on that LAN.

.6 All points of user interface shall be on standard PCs that do not require the purchase of any special software from the BMS manufacturer for use as a building operations terminal. The primary point of interface on these PCs will be a standard Web Browser.

.7 Where necessary and as dictated elsewhere in these Specifications, Servers shall be used for the purpose of providing a location for extensive archiving of system configuration data, and historical data such as trend data and operator transactions. All data stored will be through the use of a standard data base platform: Microsoft Data Engine (MSDE) or Microsoft SQL Server as dictated elsewhere in this specification.

.8 The Work of the single BMS Subcontractor shall be as defined individually and collectively in all Sections of this Division specifications together with the associated Point Sheets and Drawings and the associated interfacing Work as referenced in the related documents.

.9 The BMS Work shall consist of the provision of all labor, materials, tools, equipment, software, software licenses, software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, samples, submittals, testing, commissioning, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, temporary protection, cleaning, cutting and patching, warranties, services, and items, even though these may not be specifically mentioned in these Division documents which are required for the complete, fully functional and commissioned BMS.

.10 Provide a complete, neat and workmanlike installation. Use only manufacturer employees who are skilled, experienced, trained, and familiar with the specific equipment, software, standards and configurations to be provided for this Project.

.11 Manage and coordinate the BMS Work in a timely manner in consideration of the Project schedules. Coordinate with the associated Work of other trades so as to not impede or delay the Work of associated trades.

.12 The BMS as provided shall incorporate, at minimum, the following integrated features, functions and services:

.1 Operator information, alarm management and control functions.

.2 Enterprise-level information and control access.

.3 Information management including monitoring, transmission, archiving, retrieval, and reporting functions.

.4 Diagnostic monitoring and reporting of BMS functions.

.5 Offsite monitoring and management access.

.6 Energy management

.7 Standard applications for terminal HVAC systems.

.8 [Indoor Air Quality monitoring and control]

1.4 QUALITY ASSURANCE

.1 General

.1 The Building Management System Contractor shall be the primary manufacturer-owned branch office that is regularly engaged in the engineering, programming, installation and service of total integrated Building Management Systems.

.2 The BMS Subcontractor shall be a recognized national manufacturer, installer and service provider of BMS.

.3 If a franchised dealer is to be considered via addendum, the dealer must provide a letter written by a minimum Vice President of Operations for the specific automatic temperature control manufacturer with the following verbiage; “should the Franchise Dealer fail to provide a complete and operational system (as judged by the City/Contract Administrator), the Manufacturer will complete the project to the Contract Administrator’s satisfaction at no additional cost to the City”. This letter must be provided to the Contract Administrator along with the other supporting documentation at the time of request for equivalence.

.4 The BMS Subcontractor shall have a branch facility within a 100-mile radius of the job Site supplying complete maintenance and support services on a 24 hour, 7-day-a-week basis.

.5 As evidence and assurance of the Contractor's ability to support the City's system with service and parts, the Contractor must have been in the BMS business for at least the last ten (10) years and have successfully completed total projects of at least 10 times the value of this Contract in each of the preceding five years.

.6 The Building Management System architecture shall consist of the products of a manufacturer regularly engaged in the production of Building Management Systems, and shall be the manufacturer's latest standard of design at the time of bid.

.2 Workplace Safety And Hazardous Materials

.1 Provide a safety program in compliance with the Contract Documents.

.2 The BMS Subcontractor shall have a corporately certified comprehensive Safety Certification Manual and a designated Safety Supervisor for the Project.

.3 The Contractor and its employees and subtrades comply with federal, state and local safety regulations.

.4 The Contractor shall ensure that all subcontractors and employees have written safety programs in place that covers their scope of Work, and that their employees receive the training required by the OSHA have jurisdiction for at least each topic listed in the Safety Certification Manual.

.5 Hazards created by the Contractor or its subcontractors shall be eliminated before any further Work proceeds.

.6 Hazards observed but not created by the Contractor or its subcontractors shall be reported to either the Contractor or the City within the same day. The Contractor shall be required to avoid the hazard area until the hazard has been eliminated.

.7 The Contractor shall sign and date a safety certification form prior to any Work being performed, stating that the Contractors' company is in full compliance with the Project safety requirements.

.8 The Contractor's safety program shall include written policy and arrangements for the handling, storage and management of all hazardous materials to be used in the Work in compliance with the requirements of the AHJ at the Project Site.

.9 The Contractor's employees and subcontractor's staff shall have received training as applicable in the use of hazardous materials and shall govern their actions accordingly.

.3 Quality Management Program

.1 Designate a competent and experienced employee to provide BMS Project Management. The designated Project Manager shall be empowered to make technical, scheduling and related decisions on behalf of the BMS Subcontractor. At minimum, the Project Manager shall:

.1 Manage the scheduling of the Work to ensure that adequate materials, labor and other resources are available as needed.

.2 Manage the financial aspects of the BMS Contract.

.3 Coordinate as necessary with other trades.

.4 Be responsible for the Work and actions of the BMS workforce on Site.

1.5 REFERENCES

.1 All Work shall conform to the following Codes and Standards, as applicable:

.1 National Fire Protection Association (NFPA) Standards.

.2 National Electric Code (NEC) and applicable local Electric Code.

.3 Underwriters Laboratories (UL) listing and labels.

.4 UL 864 UUKL Smoke Control

.5 UL 268 Smoke Detectors.

.6 UL 916 Energy Management

.7 NFPA 70 - National Electrical Code.

.8 NFPA 90A - Standard For The Installation Of Air Conditioning And Ventilating Systems.

.9 NFPA 92A and 92B Smoke Purge/Control Equipment.

.10 Factory Mutual (FM).

.11 American National Standards Institute (ANSI).

.12 National Electric Manufacturer's Association (NEMA).

.13 American Society of Mechanical Engineers (ASME).

.14 American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) [user note: add ASHRAE 62 IAQ as applicable].

.15 Air Movement and Control Association (AMCA).

.16 Institute of Electrical and Electronic Engineers (IEEE).

.17 American Standard Code for Information Interchange (ASCII).

.18 Electronics Industries Association (EIA).

.19 Occupational Safety and Health Administration (OSHA).

.20 American Society for Testing and Materials (ASTM).

.21 Federal Communications Commission (FCC) including Part 15, Radio Frequency Devices.

.22 Americans Disability Act (ADA)

.23 ANSI/EIA 909.1-A-1999 (LonWorks)

.24 ANSI/ASHRAE Standard 195-2004 (BACnet)

.2 In the case of conflicts or discrepancies, the more stringent regulation shall apply.

.3 All Work shall meet the approval of the Authorities Having Jurisdiction at the project Site

1.6 WORK BY OTHERS

.1 The demarcation of Work and responsibilities between the BMS Subcontractor and other related trades shall be as outlined in the BMS RESPONSIBILITY MATRIX

BMS RESPONSIBILITY MATRIX				
WORK	**FURNISH**	**INSTALL**	**Low Volt. WIRING/TUBE**	**LINE POWER**
BMS low voltage and communication wiring	BMS	BMS	BMS	N/A
VAV box nodes	BMS	23	BMS	26
BMS conduits and raceway	BMS	BMS	BMS	BMS
Automatic dampers	BMS	23	N/A	N/A
Manual valves	22/23	22/23	N/A	N/A
Automatic valves	BMS	22/23	BMS	N/A
VAV boxes	23	23	N/A	N/A
Pipe insertion devices and taps including thermowells, flow and pressure stations.	BMS	22/23	BMS	BMS
BMS Current Switches.	BMS	BMS	BMS	N/A
BMS Control Relays	BMS	BMS	BMS	N/A
Power distribution system monitoring interfaces	26	26	BMS	26
Control air compressors	BMS	BMS	N/A	26
Concrete and/or inertia equipment pads and seismic bracing	22/23	22/23	N/A	N/A
BMS interface with Chiller controls	BMS	BMS	BMS	BMS
Chiller controls interface with BMS	23	23	BMS	26
BMS interface with Classroom unit controls	BMS	BMS	BMS	16
Classroom unit controls interface with BMS	23	23	BMS	26
ADD OTHER THIRD PARTY EQUIPMENT HERE	N/A	N/A	N/A	N/A

All BMS Nodes, equipment, housings, enclosures and panels.	BMS	BMS	BMS	BMS
Smoke Detectors	26	26	26	26
Fire/Smoke Dampers	23	23	BMS	16
Fire Dampers	23	23	N/A	N/A
Chiller Flow Switches	23	23	BMS	N/A
Boiler wiring	23	23	23	23
Water treatment system	22	22	22	26
VFDs	23	26	BMS	26
Refrigerant monitors	15	BMS	BMS	26
Computer Room A/C Unit field-mounted controls	23*	23	BMS	26
Fire Alarm shutdown relay interlock wiring	26	26	26	26
Fire Alarm smoke control relay interlock wiring	26	26	BMS	26
Fireman's Smoke Control Override Panel	26	26	26	26
Fan Coil Unit controls	BMS	BMS	BMS	26
Unit Heater controls	BMS	BMS	BMS	26
Packaged RTU space mounted controls	23*	BMS	BMS	26
Packaged RTU factory-mounted controls	15*	15	BMS	26
Packaged RTU field-mounted controls	BMS	BMS	BMS	26
Cooling Tower Vibration Switches	22	22	26	26
Cooling Tower Level Control Devices	22	22	26	26
Cooling Tower makeup water control devices	22	22	26	26
Pool Dehumidification Unit Controls	23*	23	BMS	26

Starters, HOA switches	26	26	N/A	26
Control damper actuators	BMS	BMS	BMS	26

1.7 SUBMITTALS

b) Shop Drawings, Product Data, and Samples

.1 The BMS Subcontractor shall submit a list of all shop drawings with submittals dates within 30 days of Contract award.

.2 Submittals shall be in defined packages. Each package shall be complete and shall only reference itself and previously submitted packages. The packages shall be as approved by the Contract Administrator for Contract compliance.

.3 Allow 15 working days for the review of each package by the Contract Administrator in the scheduling of the total BMS Work.

.4 Equipment and systems requiring approval of local authorities must comply with such regulations and be approved. Filing shall be at the expense of the BMS Subcontractor where filing is necessary. Provide a copy of all related correspondence and permits to the City.

.5 Prepare an index of all submittals and shop drawings for the installation. Index shall include a shop drawing identification number, Contract Documents reference and item description.

.6 The BMS Subcontractor shall correct any errors or omissions noted in the first review.

.7 Basically states that all devices using the BACnet technology will be able to communicate to each other. The controls Contractor performing the controller installation should confirm that all devices specified are able to communicate to the proposed devices. Then supply documentation such that all devices supplied will communicate to each other as required for proper operation of the system (PICS Statement, BI/BTL Listing, and ASHRAE listings).

.8 At a minimum, submit the following:

.1 BMS network architecture diagrams including all nodes and interconnections.

.2 Systems schematics, sequences and flow diagrams.

.3 Points schedule for each point in the BMS, including: Point Type, Object Name, Expanded ID, Display Units, Controller type, and Address.

.4 Samples of Graphic Display screen types and associated menus.

.5 Detailed Bill of Material list for each system or application, identifying quantities, part numbers, descriptions, and optional features.

.6 Control Damper Schedule including a separate line for each damper provided under this section and a column for each of the damper attributes, including: Code Number, Fail Position, Damper Type, Damper Operator, Duct Size, Damper Size, Mounting, and Actuator Type.

.7 Control Valve Schedules including a separate line for each valve provided under this section and a column for each of the valve attributes: Code Number, Configuration, Fail Position, Pipe Size, Valve Size, Body Configuration, Close off Pressure, Capacity, Valve CV, Design Pressure, and Actuator Type.

.8 Room Schedule including a separate line for each VAV box and/or terminal unit indicating location and address

.9 Details of all BMS interfaces and connections to the Work of other trades.

.10 Product data sheets or marked catalog pages including part number, photo and description for all products including software.

1.8 RECORD DOCUMENTATION

.1 Operation and Maintenance Manuals

.1 Three (3) copies of the Operation and Maintenance Manuals shall be provided to the Contract Administrator upon completion of the project. The entire Operation and Maintenance Manual shall be furnished on Compact Disc media, and include the following for the BMS provided:

.1 Table of contents.

.2 As-built system record drawings. Computer Aided Drawings (CAD) record drawings shall represent the as-built condition of the system and incorporate all information supplied with the approved submittal.

.3 Manufacturers product data sheets or catalog pages for all products including software.

.4 System Operator's manuals.

.5 Archive copy of all site-specific databases and sequences.

.6 BMS network diagrams.

.7 Interfaces to all third-party products and Work by other trades.

.2 The Operation and Maintenance Manual CD shall be self-contained, and include all necessary software required to access the product data sheets. A logically organized table of contents shall provide dynamic links to view and print all product data sheets. Viewer software shall provide the ability to display, zoom, and search all documents.

.2 On-Line documentation: After completion of all tests and adjustments the Contractor shall provide a copy of all as-built information and product data to be installed on a customer designated computer workstation or server

1.9 WARRANTY

.1 Standard Material and Labor Warranty:

.1 Provide a one-year labor and material warranty on the BMS.

.2 If within twelve (12) months from the date of acceptance of product, upon written notice from the City, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Subcontractor at the cost of the BMS Subcontractor.

.1 Maintain an adequate supply of materials within 100 miles of the Project Site such that replacement of key parts and labor support, including programming. Warranty Work shall be done during BMS Subcontractor's normal business hours.

Part 2 Products

2.1 GENERAL DESCRIPTION

.1 The Building Management System (BMS) shall use an open architecture and fully support a multi-vendor environment. To accomplish this effectively, the BMS shall support open communication protocol standards and integrate a wide variety of third-party devices and applications. The system shall be designed for use on the Internet, or intranets using off the shelf, industry standard technology compatible with other City provided networks.

.2 The Building Management System shall consist of the following:

.1 Standalone Network Automation Engine(s)
.2 Field Equipment Controller(s)
.3 Input/Output Module(s)
.4 Local Display Device(s)
.5 Portable Operator's Terminal(s)
.6 Distributed User Interface(s)
.7 Network processing, data storage and communications equipment
7. Other components required for a complete and working BMS

.3 The system shall be modular in nature, and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, controllers and operator devices, while re-using existing controls equipment.

.4 System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

.5 Controls must be able to interface to MSEA technology on the field device network using BACnet Protocols.

.6 Field controller shall be Johnson controls

.1 VAV Modular Assemblies

.2 Terminal Equipment Controllers

.3 Input/Output Modules

.4 Network Sensors

.5 Field Advanced Controllers

.6 Field Equipment Controllers

.7 Field Controllers shall communicate through MSTP bus to a Johnson Controls supervisory controller.

.1 NAE

.2 NCE

.8 Supervisory Controller to be integrated to existing City of Winnipeg ADX server.

.9 Controls Contractor to provide commissioning sheets for all points on field devices.

.10 Acceptable manufacturer: Johnson Control, Metasys.

2.2 BMS ARCHITECTURE

.1 Automation Network

.1 The automation network shall be based on a PC industry standard of Ethernet TCP/IP. Where used, LAN controller cards shall be standard "off the shelf" products available through normal PC vendor channels.

.2 The BMS shall network multiple user interface clients, automation engines, system controllers and application-specific controllers. Provide application and data server(s) as required for systems operation.

.3 The automation network shall be capable of operating at a communication speed of 100 Mbps, with full peer-to-peer network communication.

.4 Network Automation Engines (NAE) shall reside on the automation network.

.5 The automation network will be compatible with other enterprise-wide networks. Where indicated, the automation network shall be connected to the enterprise network and share resources with it by way of standard networking devices and practices.

.2 Control Network

.1 Network Automation Engines shall provide supervisory control over the control network and shall support all three (3) of the following communication protocols:

.1 BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9.

.2 Control networks shall provide either "Peer-to-Peer," Master-Slave, or Supervised Token Passing communications, and shall operate at a minimum communication speed of 9600 baud.

.3 DDC Controllers shall reside on the control network.

.4 Control network communication protocol shall be BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135.

.5 A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

.6 The Conformance Statements shall be submitted 10 day prior to bidding.

.3 Integration

.1 Hardwired

.1 Analog and digital signal values shall be passed from one system to another via hardwired connections.

.2 There will be one separate physical point on each system for each point to be integrated between the systems.

.2 Direct Protocol (Integrator Panel)

.1 The BMS system shall include appropriate hardware equipment and software to allow bi-directional data communications between the BMS system and 3rd party manufacturers' control panels. The BMS shall receive, react to, and return information from multiple building systems, including but not limited to the chillers, boilers, variable frequency drives, power monitoring system, and medical gas.

.2 All data required by the application shall be mapped into the Automation Engine's database, and shall be transparent to the operator.

.3 Point inputs and outputs from the third-party controllers shall have real-time interoperability with BMS software features such as: Control Software, Energy Management, Custom Process Programming, Alarm Management, Historical Data and Trend Analysis, Totalization, and Local Area Network Communications.

.3 BACnet Protocol Integration - BACnet

.1 The neutral protocol used between systems will be BACnet over Ethernet and comply with the ASHRAE BACnet standard 135-2003.

.2 A complete Protocol Implementation Conformance Statement (PICS) shall be provided for all BACnet system devices.

.3 The ability to command, share point object data, change of state (COS) data and schedules between the host and BACnet systems shall be provided.

2.3 USER INTERFACE:

.1 Dedicated Web Based User Interface

.1 Where indicated on plans the BMS Subcontractor shall provide and install a personal computer for command entry, information management, network alarm management, and database management functions. All real-time control functions, including scheduling, history collection and alarming, shall be resident in the BMS Network Automation Engines to facilitate greater fault tolerance and reliability.

.2 Dedicated User Interface Architecture – The architecture of the computer shall be implemented to conform to industry standards, so that it can accommodate applications provided by the BMS Subcontractor and by other third party applications suppliers, including but not limited to Microsoft Office Applications. Specifically it must be implemented to conform to the following interface standards.

.1 Microsoft Internet Explorer for user interface functions

.2 Microsoft Office Professional for creation, modification and maintenance of reports, sequences other necessary building management functions

.3 Microsoft Outlook or other e-mail program for supplemental alarm functionality and communication of system events, and reports

.4 Required network operating system for exchange of data and network functions such as printing of reports, trends and specific system summaries.

.5

.3 PC Hardware – The personal computer(s) shall be configured as follows:

.1 Memory – 1 GB (512 MB Minimum)

.2 CPU– Pentium 4 processor. 2.8 Hz Clock Speed (2.0 GHz minimum)

.3 Hard Drive – 80 GB free hard drive space (40GB minimum)

.4 Hard drive backup system – CD/RW, DVD/RW or network backup software provided by IT department

.5 CD ROM Drive – 32X performance

.6 Ports – (2) Serial and (1) parallel, (2) USB ports

.7 Keyboard – 101 Keyboard and 2 Button Mouse

.8 CRT configuration – 1-2 CRTs as follows:

.1 Each Display – 17” Flat Panel Monitor 1280 x 1024 resolution minimum.

.2 16 bit or higher color resolution

.3 Display card with multiple monitor support

.9 LAN communications – Ethernet communications board; 3Comm or equal in accordance with B7.

.4 Operating System Software

.1 Windows 2000 Professional or Windows XP Professional

.2 Where user interface is not provided via browser, provide complete operator workstation software package, including any hardware or software keys. Include the original installation disks and licenses for all included software, device drivers, and peripherals.

.3 Provide software registration cards to the City for all included software.

.5 Peripheral Hardware

.1 Reports printer:

.1 Printer Make – Hewlett Packard DeskJet

.2 Print Speed – 600 DPI Black, 300 DPI Color

.3 Buffer – 64 K Input Print Buffer

.4 Color Printing – Include Color Kit

.2 Distributed Web Based User Interface

.1 All features and functions of the dedicated user interface previously defined in this document shall be available on any computer connected directly or via a wide area or virtual private network (WAN/VPN) to the automation network and conforming to the following specifications.

.2 The software shall run on the Microsoft Internet Explorer (6.0 or higher) browser.

.3 Minimum hardware requirements:

.1 256 MB RAM

.2 2.0 GHz Clock Speed Pentium 4 Microprocessor.

.3 40.0 GB Hard Drive.

.4 1 Keyboard with 83 keys (minimum).

.5 SVGA 1024x768 resolution display with 64K colors and 16 bit color depth.

.6 Mouse or other pointing device

.3 User Interface Application Components

.1 Operator Interface

.1 An integrated browser based client application shall be used as the user operator interface program.

.2 All Inputs, Outputs, Setpoints, and all other parameters as defined within Part 3, shown on the design drawings, or required as part of the system software, shall be displayed for operator viewing and modification from the operator interface software.

.3 The user interface software shall provide help menus and instructions for each operation and/or application.

.4 All controller software operating parameters shall be displayed for the operator to view/modify from the user interface. These include: setpoints, alarm limits, time delays, PID tuning constants, run-times, point statistics, schedules, and so forth.

.5 The Operator Interface shall incorporate comprehensive support for functions including, but not necessarily limited to, the following:

.1 User access for selective information retrieval and control command execution

.2 Monitoring and reporting

.3 Alarm, non-normal, and return to normal condition annunciation

.4 Selective operator override and other control actions

.5 Information archiving, manipulation, formatting, display and reporting

.6 BMS internal performance supervision and diagnostics

.7 On-line access to user HELP menus

.8 On-line access to current BMS as-built records and documentation

.9 Means for the controlled re-programming, re-configuration of BMS operation and for the manipulation of BMS database information in compliance with the prevailing codes, approvals and regulations for individual BMS applications.

.6 The operation of the control system shall be independent of the user interface, which shall be used for operator communications only. Systems that rely on an operator workstation to provide supervisory control over controller execution of the sequences of operations or system communications shall not be acceptable.

.2 Navigation Trees

.1 The system will have the capability to display multiple navigation trees that will aid the operator in navigating throughout all systems and points connected. At minimum provide a tree that identifies all systems on the networks.

.2 Provide the ability for the operator to add custom trees. The operator will be able to define any logical grouping of systems or points and arrange them on the tree in any order. It shall be possible to nest groups within other groups. Provide at minimum 5 levels of nesting.

.3 The navigation trees shall be "dockable" to other displays in the user interface such as graphics. This means that the trees will appear as part of the display, but can be detached and then minimized to the Windows task bar or closed altogether. A simple keystroke will reattach the navigation to the primary display of the user interface.

.3 Alarms

.1 Alarms shall be routed directly from Network Automation Engines to PCs and servers. It shall be possible for specific alarms from specific points to be routed to specific PCs and servers. The alarm management portion of the user interface shall, at the minimum, provide the following functions:

.1 Log date and time of alarm occurrence.

.2 Generate a "Pop-Up" window, with audible alarm, informing a user that an alarm has been received.

.3 Allow a user, with the appropriate security level, to acknowledge, temporarily silence, or discard an alarm.

.4 Provide an audit trail on hard drive for alarms by recording user acknowledgment, deletion, or disabling of an alarm. The audit trail shall include the name of the user, the alarm, the action taken on the alarm, and a time/date stamp.

.5 Provide the ability to direct alarms to an e-mail address or alphanumeric pager. This must be provided in addition to the pop up window described above. Systems that use e-mail and pagers as the exclusive means of annunciating alarms are not acceptable.

.6 Any attribute of any object in the system may be designated to report an alarm.

.2 The BMS shall annunciate diagnostic alarms indicating system failures and non-normal operating conditions

.3 The BMS shall annunciate application alarms at minimum, as required by Part 3.

.4 Reports and Summaries

.1 Reports and Summaries shall be generated and directed to the user interface displays, with subsequent assignment to printers, or disk. As a minimum, the system shall provide the following reports:

.1 All points in the BMS

.2 All points in each BMS application

.3 All points in a specific controller

.4 All points in a user-defined group of points

.5 All points currently in alarm

.6 All points locked out

.7 All BMS schedules

.8 All user defined and adjustable variables, schedules, interlocks and the like.

.2 Summaries and Reports shall be accessible via standard UI functions and not dependent upon custom programming or user defined HTML pages.

.3 Selection of a single menu item, tool bar item, or tool bar button shall print any displayed report or summary on the system printer for use as a building management and diagnostics tool.

.4 The system shall allow for the creation of custom reports and queries via a standard web services XML interface and commercial off-the-shelf software such as Microsoft Access, Microsoft Excel, or Crystal Reports.

.5 Schedules

.1 A graphical display for time-of-day scheduling and override scheduling of building operations shall be provided. At a minimum, the following functions shall be provided:

.1 Weekly schedules

.2 Exception Schedules

.3 Monthly calendars.

.2 Weekly schedules shall be provided for each group of equipment with a specific time use schedule.

.3 It shall be possible to define one or more exception schedules for each schedule including references to calendars

.4 Monthly calendars shall be provided that allow for simplified scheduling of holidays and special days for a minimum of five years in advance. Holidays and special days shall be user-selected with the pointing device or keyboard, and shall automatically reschedule equipment operation as previously defined on the exception schedules.

.5 Changes to schedules made from the User Interface shall directly modify the Network Automation Engine schedule database.

.6 Schedules and Calendars shall comply with ASHRAE SP135/2003 BACnet Standard.

.7 Selection of a single menu item or tool bar button shall print any displayed schedule on the system printer for use as a building management and diagnostics tool.

.6 Password

.1 Multiple-level password access protection shall be provided to allow the user/manager to user interface control, display, and database manipulation capabilities deemed appropriate for each user, based on an assigned password.

.2 Each user shall have the following: a user name (24 characters minimum), a password (12 characters minimum), and access levels.

.3 The system shall allow each user to change his or her password at will.

.4 When entering or editing passwords, the system shall not echo the actual characters for display on the monitor.

.5 A minimum of five levels of access shall be supported individually or in any combination as follows:

.1 Level 1 = View Data

.2 Level 2 = Command

.3 Level 3 = Operator Overrides

.4 Level 4 = Database Modification

.5 Level 5 = Database Configuration

.6 Level 6 = All privileges, including Password Add/Modify

.6 A minimum of 100 unique passwords shall be supported.

.7 Operators shall be able to perform only those commands available for their respective passwords. Display of menu selections shall be limited to only those items defined for the access level of the password used to log-on.

.8 The system shall automatically generate a report of log-on/log-off and system activity for each user. Any action that results in a change in the operation or configuration of the control system shall be recorded, including: modification of point values, schedules or history collection parameters, and all changes to the alarm management system, including the acknowledgment and deletion of alarms.

.7 Screen Manager - The User Interface shall be provided with screen management capabilities that allow the user to activate, close, and simultaneously manipulate a minimum of 4 active display windows plus a network or user defined navigation tree.

.8 Dynamic Color Graphics

.1 The graphics application program shall be supplied as an integral part of the User Interface. Browser or Workstation applications that rely only upon HTML pages shall not be acceptable.

.2 The graphics applications shall include a create/edit function and a runtime function. The system architecture shall support an unlimited number of graphics documents (graphic definition files) to be generated and executed.

The graphics shall be able to display and provide animation based on real-time data that is acquired, derived, or entered.

.3 Graphics runtime functions – A maximum of 16 graphic applications shall be able to execute at any one time on a user interface or workstation with 4 visible to the user. Each graphic application shall be capable of the following functions:

.1 All graphics shall be fully scalable

.2 The graphics shall support a maintained aspect ratio.

.3 Multiple fonts shall be supported.

.4 Unique background shall be assignable on a per graphic basis.

.5 The color of all animations and values on displays shall indicate if the status of the object attribute.

.4 Operation from graphics – It shall be possible to change values (setpoints) and states in system controlled equipment by using drop-down windows accessible via the pointing device

.5 Graphic editing tool – A graphic editing tool shall be provided that allows for the creation and editing of graphic files. The graphic editor shall be capable of performing/defining all animations, and defining all runtime binding.

.1 The graphic editing tool shall in general provide for the creation and positioning of point objects by dragging from tool bars or drop-downs and positioning where required.

.2 In addition, the graphic editing tool shall be able to add additional content to any graphic by importing backgrounds in the SVG, BMP or JPG file formats.

.6 Aliasing – Many graphic displays representing part of a building and various building components are exact duplicates, with the exception that the various variables are bound to different field values. Consequently, it shall be possible to bind the value of a graphic display to aliases, as opposed to the physical field tags.

.9 Historical trending and data collection

.1 Each Automation Engine shall store trend and point history data for all analog and digital inputs and outputs, as follows:

.1 Any point, physical or calculated, may be designated for trending. Three methods of collection shall be allowed:

Defined time interval

Upon a change of value

.2 Each Automation Engine shall have the capability to store multiple samples for each physical point and software variable based upon available memory, including an individual sample time/date stamp. Points may be assigned to multiple history trends with different collection parameters.

.2 Trend and change of value data shall be stored within the engine and uploaded to a dedicated trend database or exported in a selectable data

format via a provided data export utility. Uploads to a dedicated database shall occur based upon one of the following: user-defined interval, manual command, or when the trend buffers are full. Exports shall be as requested by the user or on a time scheduled basis.

.3 The system shall provide a configurable data storage subsystem for the collection of historical data. Data can be stored in either Microsoft Access or SQL database format.

.10 Trend data viewing and analysis

.1 Provide a trend viewing utility that shall have access to all database points.

.2 It shall be possible to retrieve any historical database point for use in displays and reports by specifying the point name and associated trend name.

.3 The trend viewing utility shall have the capability to define trend study displays to include multiple trends

.4 Displays shall be able to be single or stacked graphs with on-line selectable display characteristics, such as ranging, color, and plot style.

.5 Display magnitude and units shall both be selectable by the operator at any time without reconfiguring the processing or collection of data. This is a zoom capability.

.6 Display magnitude shall automatically be scaled to show full graphic resolution of the data being displayed.

.7 Trend studies shall be capable of calculating and displaying calculated variables including highest value, lowest value and time based accumulation.

.4 Portable Operator Terminal

.1 For systems that do not provide full access to systems configuration and definition via the Browser Based user interface the BMS Subcontractor shall provide a portable operator terminal for programming purposes. The terminal shall be configured as follows:

.1 Personal Laptop Computer Manufacturer – Dell, Compaq or HP

.2 1 GB RAM (256 MB minimum) – Windows 2000 or XP Professional.

.3 1.8 GHz Clock Speed Pentium 4 Microprocessor (800 MHz minimum).

.4 40 GB Hard Drive. (40 GB minimum)

.5 (1) CD-ROM Drive, 32x speed.

.6 (1) Serial (1) Parallel (2) USB ports

.7 1 Keyboard with 83 keys (minimum).

.8 Integral 2 button Track Point or Track Ball.

.9 10” SVGA 1024x768 resolution color display

.10 Two PCMCIA Type II or one Type III card slot.

.11 Complete operator workstation software package, including any hardware or software.

.12 Original printed manuals for all software and peripherals.

.13 Original installation disks or CD for all software, device drivers, and peripherals.

.14 Software registration cards for all included software shall be provided to the City.

.15 Carrying case.

.16 Spare battery.

.17 External power supply/battery charger.

.2 Proprietary Portable Terminal

.1 Manufacturers providing proprietary portable terminals shall submit technical data sheets for the terminal and all associated software and hardware.

.2 The proprietary terminal shall meet the same operator interface software requirements as specified above.

.3 Software

.1 Portable operator terminals shall support all controllers within the system on a direct-connect communications basis.

.2 When used to access First or Second Tier controllers, the portable operator terminal shall utilize the standard operator workstation software, as previously defined.

.3 When used to access Application Specific Controllers, the portable operator terminal shall utilize either the standard operator workstation software, as previously defined, or controller-specific utility software.

2.4 NETWORK AUTOMATION ENGINE (NAE)

.1 Network Automation Engine (**NAE**)

.1 The Network Automation Engine (NAE) shall be a fully user-programmable, supervisory controller. The NAE shall monitor the network of distributed application-specific controllers, provide global strategy and direction, and communicate on a peer-to-peer basis with other Network Automation Engines.

.2 Automation network – The NAE shall reside on the automation network and shall support a subnet of system controllers.

.3 User Interface – Each NAE shall have the ability to deliver a web based User Interface (UI) as previously described. All computers connected physically or virtually to the automation network shall have access to the web based UI.

.1 The web based UI software shall be imbedded in the NAE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.

.2 The NAE shall support up four (4) concurrent users.

.3 The web based user shall have the capability to access all system data through one NAE.

.4 Remote users connected to the network through an Internet Service Provider (ISP) or telephone dial up shall also have total system access through one NAE.

.5 Systems that require the user to address more than one NAE to access all system information are not acceptable.

.6 The NAE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NAE.

.7 Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.

.8 The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:

.1 Configuration

.2 Commissioning

.3 Data Archiving

.4 Monitoring

.5 Commanding

.6 System Diagnostics

.9 Systems that require workstation software or modified web browsers are not acceptable.

.10 The NAE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.

.4 Processor – The NAE shall be microprocessor-based with a minimum word size of 32 bits. The NAE shall be a multi-tasking, multi-user, and real-time digital control processor. Standard operating systems shall be employed. NAE size and capability shall be sufficient to fully meet the requirements of this Specification.

.5 Memory – Each NAE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.

.6 Hardware Real Time Clock – The NAE shall include an integrated, hardware-based, real-time clock.

.7 The NAE shall include troubleshooting LED indicators to identify the following conditions:

.1 Power - On/Off

.2 Ethernet Traffic – Ethernet Traffic/No Ethernet Traffic

.3 Ethernet Connection Speed – 10 Mbps/100 Mbps

.4 FC Bus – Normal Communications/No Field Communications

.5 Peer Communication – Data Traffic Between NAE Devices

.6 Run – NAE Running/NAE In Startup/NAE Shutting Down/Software Not Running

.7 Bat Fault – Battery Defective, Data Protection Battery Not Installed

.8 Fault – General Fault

.9 Modem RX – NAE Modem Receiving Data

.10 Modem TX – NAE Modem Transmitting Data

.8 Communications Ports – The NAE shall provide the following ports for operation of operator Input/Output (I/O) devices, such as industry-standard computers, modems, and portable operator's terminals.

.1 Up to two (2) USB port

.2 Up to two (2) URS-232 serial data communication port

.3 Up to two (2) RS-485 port

.4 One (1) Ethernet port

.9 Diagnostics – The NAE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Automation Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.

.10 Power Failure – In the event of the loss of normal power, The NAE shall continue to operate for a user adjustable period of up to 10 minutes after which there shall be an orderly shutdown of all programs to prevent the loss of database or operating system software.

.1 During a loss of normal power, the control sequences shall go to the normal system shutdown conditions. All critical configuration data shall be saved into Flash memory.

.2 Upon restoration of normal power and after a minimum off-time delay, the controller shall automatically resume full operation without manual intervention through a normal soft-start sequence.

.11 Certification – The NAE shall be listed by Underwriters Laboratories (UL).

.12 Controller network – The NAE shall support the following communication protocols on the controller network:

.1 The NAE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.

.1 A BACnet Protocol Implementation Conformance Statement shall be provided for each controller device (master or slave) that will communicate on the BACnet MS/TP Bus.

.2 The Conformance Statements shall be submitted 10 day prior to bidding.

.3 The NAE shall support a minimum of 100 control devices.

2.5 DDC SYSTEM CONTROLLERS

.1 Field Equipment Controller (**FEC**)

.1 The Field Equipment Controller (FEC) shall be a fully user-programmable, digital controller that communicates via BACnet MS/TP protocol.

.2 The FEC shall employ a finite state control engine to eliminate unnecessary conflicts between control functions at crossover points in their operational sequences. Suppliers using non-state based DDC shall provide separate control strategy diagrams for all controlled functions in their submittals.

.3 Controllers shall be factory programmed with a continuous adaptive tuning algorithm that senses changes in the physical environment and continually adjusts loop tuning parameters appropriately. Controllers that require manual tuning of loops or perform automatic tuning on command only shall not be acceptable.

.4 The FEC shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

.5 The FEC shall include a removable base to allow pre-wiring without the controller.

.6 The FEC shall include troubleshooting LED indicators to identify the following conditions:

.1 Power On

.2 Power Off

.3 Download or Startup in progress, not ready for normal operation

.4 No Faults

.5 Device Fault

.6 Field Controller Bus - Normal Data Transmission

.7 Field Controller Bus - No Data Transmission

.8 Field Controller Bus - No Communication

.9 Sensor-Actuator Bus - Normal Data Transmission

.10 Sensor-Actuator Bus - No Data Transmission

.11 Sensor-Actuator Bus - No Communication

.7 The FEC shall accommodate the direct wiring of analog and binary I/O field points.

.8 The FEC shall support the following types of inputs and outputs:

.1 Universal Inputs - shall be configured to monitor any of the following:

.1 Analog Input, Voltage Mode

.2 Analog Input, Current Mode

.3 Analog Input, Resistive Mode

.4 Binary Input, Dry Contact Maintained Mode

.5 Binary Input, Pulse Counter Mode

.2 Binary Inputs - shall be configured to monitor either of the following:

.1 Dry Contact Maintained Mode

.2 Pulse Counter Mode

.3 Analog Outputs - shall be configured to output either of the following

.1 Analog Output, Voltage Mode

.2 Analog Output, current Mode

.4 Binary Outputs - shall output the following:

.1 24 VAC Triac

.5 Configurable Outputs - shall be capable of the following:

.1 Analog Output, Voltage Mode

.2 Binary Output Mode

.9 The FEC shall have the ability to reside on a Field Controller Bus (FC Bus).

.1 The FC Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.

.2 The FC Bus shall support communications between the FECs and the NAE.

.3 The FC Bus shall also support Input/Output Module (IOM) communications with the FEC and with the NAE.

.4 The FC Bus shall support a minimum of 100 IOMs and FEC in any combination.

.5 The FC Bus shall operate at a maximum distance of 15,000 Ft. between the FEC and the furthest connected device.

.6

.10 The FEC shall have the ability to monitor and control a network of sensors and actuators over a Sensor-Actuator Bus (SA Bus).

.1 The SA Bus shall be a Master-Slave/Token-Passing (MS/TP) Bus supporting BACnet Standard protocol SSPC-135, Clause 9.

.2 The SA Bus shall support a minimum of 10 devices per trunk.

.3 The SA Bus shall operate at a maximum distance of 1,200 Ft. between the FEC and the furthest connected device.

.11 The FEC shall have the capability to execute complex control sequences involving direct wired I/O points as well as input and output devices communicating over the FC Bus or the SA Bus.

.12 The FEC shall support, but not be limited to, the following:

.1 Hot water, chilled water/central plant applications

.2 Built-up air handling units for special applications

Terminal units

.3 Special programs as required for systems control

2.6 FIELD DEVICES

.1 Input/Output Module **(IOM)**

.1 The Input/Output Module (IOM) provides additional inputs and outputs for use in the FEC.

.2 The IOM shall communicate with the FEC over either the FC Bus or the SA Bus using BACnet Standard protocol SSPC-135, Clause 9.

.3 The IOM shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

.4 The IOM shall have a minimum of 4 points to a maximum of 17 points.

.5 The IOM shall support the following types of inputs and outputs:

.1 Universal Inputs - shall be configured to monitor any of the following:

.1 Analog Input, Voltage Mode

.2 Analog Input, Current Mode

.3 Analog Input, Resistive Mode

.4 Binary Input, Dry Contact Maintained Mode

.5 Binary Input, Pulse Counter Mode

.2 Binary Inputs - shall be configured to monitor either of the following:

.1 Dry Contact Maintained Mode

.2 Pulse Counter Mode

.3 Analog Outputs - shall be configured to output either of the following

.1 Analog Output, Voltage Mode

.2 Analog Output, current Mode

.4 Binary Outputs - shall output the following:

.1 24 VAC Triac

.5 Configurable Outputs - shall be capable of the following:

.1 Analog Output, Voltage Mode

.2 Binary Output Mode

.6 The IOM shall include troubleshooting LED indicators to identify the following conditions:

.1 Power On

.2 Power Off

.3 Download or Startup in progress, not ready for normal operation

.4 No Faults

.5 Device Fault

.6 Normal Data Transmission

.7 No Data Transmission

.8 No Communication

.2 Networked Thermostat **(TEC)**

.1 The Networked Thermostats shall be capable of controlling the following:

.1 A four pipe fan coil system with multi-speed fan control.

.2 A pressure dependant Variable Air Volume System or similar zoning type system using reheat.

.3 A two pipe fan coil with a single speed fan.

.2 The Networked Thermostat shall communicate over the Field Controller Bus using BACnet Standard protocol SSPC-135, Clause 9.

.1 The Networked Thermostat shall support remote read/write and parameter adjustment from the web based User Interfaceable through a Network Automation Engine.

.3 The Networked Thermostat shall include an intuitive User Interface providing plain text messages.

.1 Two line, 8 character backlit display

.2 LED indicators for Fan, Heat, and Cool status

.3 Five (5) User Interface Keys

.1 Mode

.2 Fan

.3 Override

.4 Degrees C/F

.5 Up/Down

.4 The display shall continuously scroll through the following parameters:

.1 Room Temperature

.2 System Mode

.3 Schedule Status – Occupied/Unoccupied/Override

.4 Applicable Alarms

.4 The Networked Thermostats shall provide the flexibility to support the following inputs:

.1 Integral Indoor Air Temperature Sensor

.2 Duct Mount Air Temperature Sensor

.3 Remote Indoor Air Temperature Sensor with Occupancy Override and LED Indicator.

.4 Two configurable binary inputs

.5 The Networked Thermostats shall provide the flexibility to support the following outputs:

.1 Three Speed Fan Control

.2 On/Off Control

.3 Floating Control

.4 Proportional (0 to 10V) Control

.6 The Networked Thermostat shall provide a minimum of six (6) levels of keypad lockout.

.7 The Networked Thermostat shall provide the flexibility to adjust the following parameters:

.1 Adjustable Temporary Occupancy from 0 to 24 hours

.2 Adjustable heating/cooling deadband from 2º F to 5º F

.3 Adjustable heating/cooling cycles per hour from 4 to 8

.8 The Networked Thermostat shall employ nonvolatile electrically erasable programmable read-only memory (EEPROM) for all adjustable parameters.

.3 VAV Modular Assembly **(VMA)**

.1 The VAV Modular Assembly shall provide both standalone and networked direct digital control of pressure-independent, variable air volume terminal units. It shall address both single and dual duct applications.

.2 The VAV Modular Assembly shall communicate over the FC Bus using BACnet Standard protocol SSPC-135, Clause 9.

.3 The VAV Modular Assembly shall have internal electrical isolation for AC power, DC inputs, and MS/TP communications. An externally mounted isolation transformer shall not be acceptable.

.4 The VAV Modular Assembly shall be a configurable digital controller with integral differential pressure transducer and damper actuator. All components shall be connected and mounted as a single assembly that can be removed as one piece.

.5 The VAV Modular Assembly shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.

.6 The integral damper actuator shall be a fast response stepper motor capable of stroking 90 degrees in 30 seconds for quick damper positioning to speed commissioning and troubleshooting tasks.

.7 The controller shall determine airflow by dynamic pressure measurement using an integral dead-ended differential pressure transducer. The transducer shall be maintenance-free and shall not require air filters.

.8 Each controller shall have the ability to automatically calibrate the flow sensor to eliminate pressure transducer offset error due to ambient temperature / humidity effects.

.9 The controller shall utilize a proportional plus integration (PI) algorithm for the space temperature control loops.

.10 Each controller shall continuously, adaptively tune the control algorithms to improve control and controller reliability through reduced actuator duty cycle. In addition, this tuning reduces commissioning costs, and eliminates the maintenance costs of manually re-tuning loops to compensate for seasonal or other load changes.

.11 The controller shall provide the ability to download and upload VMA configuration files, both locally and via the communications network. Controllers shall be able to be loaded individually or as a group using a zone schedule generated spreadsheet of controller parameters.

.12 Control setpoint changes initiated over the network shall be written to VMA non-volatile memory to prevent loss of setpoint changes and to provide consistent operation in the event of communication failure.

.13 The controller firmware shall be flash-upgradeable remotely via the communications bus to minimize costs of feature enhancements.

.14 The controller shall provide fail-soft operation if the airflow signal becomes unreliable, by automatically reverting to a pressure-dependent control mode.

.15 The controller shall interface with balancer tools that allow automatic recalculation of box flow pickup gain (“K” factor), and the ability to directly command the airflow control loop to the box minimum and maximum airflow setpoints.

.16 Controller performance shall be self-documenting via on-board diagnostics. These diagnostics shall consist of control loop performance measurements executing at each control loop’s sample interval, which may be used to continuously monitor and document system performance. The VMA shall calculate exponentially weighted moving averages (EWMA) for each of the following. These metrics shall be available to the end user for efficient management of the VAV terminals.

.1 Absolute temperature loop error.

.2 Signed temperature loop error.

.3 Absolute airflow loop error.

.4 Signed airflow loop error.

.5 Average damper actuator duty cycle.

.17 The controller shall detect system error conditions to assist in managing the VAV zones. The error conditions shall consist of:

.1 Unreliable space temperature sensor.

.2 Unreliable differential pressure sensor.

.3 Starved box.

.4 Actuator stall

.5 Insufficient cooling.

.6 Insufficient heating.

The controller shall provide a flow test function to view damper position vs. flow in a graphical format. The information would alert the user to check damper position. The VMA would also provide a method to calculate actuator duty cycle as an indicator of damper actuator runtime.

.18 The controller shall provide a compliant interface for ASHRAE Standard 62-1989 (indoor air quality), and shall be capable of resetting the box minimum airflow Based on the percent of outdoor air in the primary air stream.

.19 The controller shall comply with ASHRAE Standard 90.1 (energy efficiency) by preventing simultaneous heating and cooling, and where the control strategy requires reset of airflow while in reheat, by modulating the box reheat device fully open prior to increasing the airflow in the heating sequence.

.20 Inputs:

.1 Analog inputs with user defined ranges shall monitor the following analog signals, without the addition of equipment outside the terminal controller cabinet:

.1 0-10 VDC Sensors

.2 1000ohm RTDs

.3 NTC Thermistors

.2 Binary inputs shall monitor dry contact closures. Input shall provide filtering to eliminate false signals resulting from input “bouncing.”

.3 For noise immunity, the inputs shall be internally isolated from power, communications, and output circuits.

.4 Provide side loop application for humidity control.

.21 Outputs

.1 Analog outputs shall provide the following control outputs:

.1 0-10 VDC

.2 Binary outputs shall provide a SPST Triac output rated for 500mA at 24 VAC.

.3 For noise immunity, the outputs shall be internally isolated from power, communications, and other output circuits.

.22 Application Configuration

.1 The VAV Modular Assembly shall be configured with a software tool that provides a simple Question/Answer format for developing applications and downloading.

.23 Sensor Support

.1 The VAV Modular Assembly shall communicate over the Sensor-Actuator Bus (SA Bus) with a Network Sensor.

.2 The VMA shall support an LCD display room sensor.

.3 The VMA shall also support standard room sensors as defined by analog input requirements.

.4 The VMA shall support humidity sensors defined by the AI side loop.

.4 Network Sensors **(NS)**

.1 The Network Sensors (NS) shall have the ability to monitor the following variables as required by the systems sequence of operations:

.1 Zone Temperature

.2 Zone humidity

.3 Zone setpoint

.2 The NS shall transmit the zone information back to the controller on the Sensor-Actuator Bus (SA Bus) using BACnet Standard protocol SSPC-135, Clause 9.

.3 The Network Sensors shall include the following items:

.1 A backlit Liquid Crystal Display (LCD) to indicate the Temperature, Humidity and Setpoint.

.2 An LED to indicate the status of the Override feature.

.3 A button to toggle the temperature display between Fahrenheit and Celsius.

.4 A button to initiate a timed override command

.4 The NS shall be available with either screw terminals or phone jack.

.5 The NS shall be available in either surface mount or wall mount styles.

.5 Many-To-One Wireless Room Temperature Sensor System **(WRS)**

.1 The Many-To-One System Receiver (WRS Receiver) shall receive wireless Radio Frequency (RF) signals containing temperature data from multiple Wireless Room Temperature Sensors (WRS Sensors).

.1 The WRS Receiver shall use direct sequence spread spectrum RF technology.

.2 The WRS Receiver shall operate on the 2.4 GHZ ISM Band.

.3 The WRS Receiver shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.

.4 The WRS Receiver shall be FCC compliant to CFR Part 15 subpart B Class A.

.5 The WRS Receiver shall operate as a bidirectional transceiver with the sensors to confirm and synchronize data transmission.

.6 The WRS Receiver shall be capable of communication with WRS Sensors up to a distance of 200 Feet.

.7 The WRS Receiver shall be assembled in a plenum rated plastic housing with flammability rated to UL94-5VB.

.8 The WRS Receiver shall have LED indicators to provide information regarding the following conditions:

.1 Power On/Off

.2 Ethernet – Receiver Activity/No Activity

.3 Wireless Normal Mode – Transmission from sensors/No Transmission

.4 Wireless Rapid Transmit Mode – No transmission/ weak signal/Adequate signal/Excellent signal

.5 Ethernet Connection – No connection/10Mbps connection/100Mbps connection

.6 Network Activity – No Network Activity/Half-Duplex Communication/Full-Duplex Communication

.2 The WRS Sensors shall sense and report room temperatures to the WRS Receiver.

.1 The WRS Sensors shall use direct sequence spread spectrum RF technology.

.2 The WRS Sensors shall operate on the 2.4 GHZ ISM Band.

.3 The WRS Sensors shall meet the IEEE 802.15.4 standard for low-power, low duty-cycle RF transmitting systems.

.4 The WRS sensors shall be FCC compliant to CFR Part 15 subpart B Class A.

.5 The WRS sensors shall be available with

.1 Warmer/Cooler Set Point Adjustment

.2 No Set Point Adjustment

.3 Set Point Adjustment Scale – 55 to 85º F.

.6 The WRS sensors shall be assembled in NEMA 1 plastic housings.

2.7 SYSTEM TOOLS

.1 System Configuration Tool **(SCT)**

.1 The Configuration Tool shall be a software package enabling a computer platform to be used as a stand-alone engineering configuration tool for a Network Automation Engine (NAE) or a Network Integration Engine (NIE).

.2 The configuration tool shall provide an archive database for the configuration and application data.

.3 The configuration tool shall have the same look-and-feel at the User Interface (UI) regardless of whether the configuration is being done online or offline.

.4 The configuration tool shall include the following features:

.1 Basic system navigation tree for connected networks

.2 Integration of Metasys N1, LonWorks, and BACnet enabled devices

.3 Customized user navigation trees

.4 Point naming operating parameter setting

.5 Graphic diagram configuration

.6 Alarm and event message routing

.7 Graphical logic connector tool for custom programming

.8 Downloading, uploading, and archiving databases

.5 The configuration tool shall have the capability to automatically discover field devices on connected buses and networks. Automatic discovery shall be available for the following field devices:

.1 BACnet Devices

.6 The configuration tool shall be capable of programming the Field Equipment Controllers.

.1 The configuration tool shall provide the capability to configure, simulate, and commission the Field Equipment Controllers.

.2 The configuration tool shall allow the FECs to be run in Simulation Mode to verify the applications.

.3 The configuration tool shall contain a library of standard applications to be used for configuration.

.7 The configuration tool shall be capable of programming the field devices.

.1 The configuration tool shall provide the capability to configure, simulate, and commission the field devices.

.2 The configuration tool shall allow the field devices to be run in Simulation Mode to verify the applications.

.3 The configuration tool shall contain a library of standard applications to be used for configuration

.8 A wireless access point shall allow a wireless enabled portable PC to make a temporary Ethernet connection to the automation network.

.1 The wireless connection shall allow the PC to access configuration tool through the web browser using the User Interface (UI).

.2 The wireless use of configuration tool shall be the same as a wired connection in every respect.

.3 The wireless connection shall use the Bluetooth Wireless Technology.

.2 Wireless MS/TP Converter (BTCVT)

.1 The converter shall provide a temporary wireless connection between the SA or FC Bus and a wireless enabled portable PC.

.2 The converter shall support downloading and troubleshooting FEC and field devices from the PC over the wireless connection.

.3 The converter shall employ Bluetooth Wireless Technology.

.4 The converter shall be powered through a connection to either the Sensor-Actuator (SA) or the Field Controller (FC) Bus.

.5 The converter shall operate over a minimum of thirty three (33) feet within a building.

.6 The converter shall have LED indicators to provide information regarding the following conditions:

.1 Power - On/Off

.2 Fault – Fault/No Fault

.3 SA/FC Bus – Bus Activity/ No Bus Activity

.4 Blue – Bluetooth Communication Established/ Bluetooth Communication Not Established

.7 The SWCVT shall comply with FCC Part 15.247 regulations for low-power unlicensed transmitters.

.3 Handheld VAV Balancing Sensor (ATV)

.1 The sensor shall be a light weight portable device of dimensions not more than 3.2 x 3.2 x 1.0 inches.

.2 The sensor shall be capable of displaying data and setting balancing parameters for VAV control applications.

.3 The sensor shall be powered through a connection to either the Sensor-Actuator (SA) or the Field Controller (FC) Bus.

.4 The sensor shall be a menu driven device that shall modify itself automatically depending upon what type of application resides in the controller.

.5 The sensor shall contain a dial and two buttons to navigate through the menu and to set balancing parameters.

.6 The sensor shall provide an adjustable time-out parameter that will return the controller to normal operation if the balancing operation is aborted or abandoned.

.7 The sensor shall include the following

.1 5 foot retractable cable

.2 Laminated user guide

.3 Nylon caring case

.8 The sensor shall be Underwriters Laboratory UL 916 listed and CSA certified C22.2 N. 205, CFR47.

2.8 INPUT DEVICES

.1 General Requirements

.1 Installation, testing, and calibration of all sensors, transmitters, and other input devices shall be provided to meet the system requirements.

.2 Temperature Sensors

.1 General Requirements:

.1 Sensors and transmitters shall be provided, as outlined in the input/output summary and sequence of operations.

.2 The temperature sensor shall be of the resistance type, and shall be either two-wire 1000 ohm nickel RTD, or two-wire 1000 ohm platinum RTD.

.3 The following point types (and the accuracy of each) are required, and their associated accuracy values include errors associated with the sensor, lead wire, and A to D conversion:

Point Type	**Accuracy**
Chilled Water	± .5°F.
Room Temp	± .5°F.
Duct Temperature	± .5°F.
All Others	± .75°F.

.2 Room Temperature Sensors

.1 Room sensors shall be constructed for either surface or wall box mounting.

.2 Room sensors shall have the following options when specified:

.1 Setpoint reset slide switch providing a ±3 degree (adjustable) range.

.2 Individual heating/cooling setpoint slide switches.

.3 A momentary override request push button for activation of after-hours operation.

.4 Analog thermometer.

.3 Room Temperature Sensors with Integral Display

.1 Room sensors shall be constructed for either surface or wall box mounting.

.2 Room sensors shall have an integral LCD display and four button keypad with the following capabilities:

.1 Display room and outside air temperatures.

.2 Display and adjust room comfort setpoint.

.3 Display and adjust fan operation status.

.4 Timed override request push button with LED status for activation of after-hours operation.

.5 Display controller mode.

.6 Password selectable adjustment of setpoint and override modes.

.4 Thermo wells

.1 When thermo wells are required, the sensor and well shall be supplied as a complete assembly, including wellhead and Greenfield fitting.

.2 Thermo wells shall be pressure rated and constructed in accordance with the system working pressure.

.3 Thermo wells and sensors shall be mounted in a threadolet or 1/2" NFT saddle and allow easy access to the sensor for repair or replacement.

.4 Thermo wells shall be constructed of 316 stainless steel.

.5 Outside Air Sensors

.1 Outside air sensors shall be designed to withstand the environmental conditions to which they will be exposed. They shall also be provided with a solar shield.

.2 Sensors exposed to wind velocity pressures shall be shielded by a perforated plate that surrounds the sensor element.

.3 Temperature transmitters shall be of NEMA 3R construction and rated for ambient temperatures.

.6 Duct Mount Sensors

.1 Duct mount sensors shall mount in an electrical box through a hole in the duct, and be positioned so as to be easily accessible for repair or replacement.

.2 Duct sensors shall be insertion type and constructed as a complete assembly, including lock nut and mounting plate.

.3 For outdoor air duct applications, a weatherproof mounting box with weatherproof cover and gasket shall be used.

.7 Averaging Sensors

.1 For ductwork greater in any dimension that 48 inches and/or where air temperature stratification exists, an averaging sensor with multiple sensing points shall be used.

.2 For plenum applications, such as mixed air temperature measurements, a string of sensors mounted across the plenum shall be used to account for stratification and/or air turbulence. The averaging string shall have a minimum of 4 sensing points per 12-foot long segment.

.3 Capillary supports at the sides of the duct shall be provided to support the sensing string.

.8 Acceptable Manufacturers: Johnson Controls, Setra.

.3 Humidity Sensors

.1 The sensor shall be a solid-state type, relative humidity sensor of the Bulk Polymer Design. The sensor element shall resist service contamination.

.2 The humidity transmitter shall be equipped with non-interactive span and zero adjustments, a 2-wire isolated loop powered, 4-20 mA, 0-100% linear proportional output.

.3 The humidity transmitter shall meet the following overall accuracy, including lead loss and Analog to Digital conversion. 3% between 20% and 80% RH @ 77 Deg F unless specified elsewhere.

.4 Outside air relative humidity sensors shall be installed with a rain proof, perforated cover. The transmitter shall be installed in a NEMA 3R enclosure with sealtite fittings and stainless steel bushings.

.5 A single point humidity calibrator shall be provided, if required, for field calibration. Transmitters shall be shipped factory pre-calibrated.

.6 Duct type sensing probes shall be constructed of 304 stainless steel, and shall be equipped with a neoprene grommet, bushings, and a mounting bracket.

.7 Acceptable Manufacturers: Johnson Controls, Veris Industries, and Mamac.

.4 Differential Pressure Transmitters

.1 General Air and Water Pressure Transmitter Requirements:

.1 Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.

.2 Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.

.3 Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and City permanent, easy-to-use connection.

.4 A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

.2 Low Differential Water Pressure Applications (0” - 20” w.c.)

.1 The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of flow meter differential pressure or water pressure sensing points.

.2 The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

.1 .01-20” w.c. input differential pressure range.

.2 4-20 mA output.

.3 Maintain accuracy up to 20 to 1 ratio turndown.

.4 Reference Accuracy: +0.2% of full span.

.3 Acceptable Manufacturers: Setra and Mamac.

.3 Medium to High Differential Water Pressure Applications (Over 21” w.c.)

.1 The differential pressure transmitter shall meet the low pressure transmitter specifications with the following exceptions:

.1 Differential pressure range 10” w.c. to 300 PSI.

.2 Reference Accuracy: $\pm$1% of full span (includes non-linearity, hysteresis, and repeatability).

.2 Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

.3 Acceptable Manufacturers: Setra and Mamac.

.4 Building Differential Air Pressure Applications (-1” to +1” w.c.)

.1 The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

.2 The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

.1 -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)

.2 4-20 mA output.

.3 Maintain accuracy up to 20 to 1 ratio turndown.

.4 Reference Accuracy: +0.2% of full span.

.3 Acceptable Manufacturers: Johnson Controls and Setra.

.5 Low Differential Air Pressure Applications (0” to 5” w.c.)

.1 The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.

.2 The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:

.1 (0.00 - 1.00” to 5.00”) w.c. input differential pressure ranges. (Select range appropriate for system application.)

.2 4-20 mA output.

.3 Maintain accuracy up to 20 to 1 ratio turndown.

.4 Reference Accuracy: +0.2% of full span.

.3 Acceptable Manufacturers: Johnson Controls and Setra.

.6 Medium Differential Air Pressure Applications (5” to 21” w.c.)

.1 The pressure transmitter shall be similar to the Low Air Pressure Transmitter, except that the performance specifications are not as severe. Differential pressure transmitters shall be provided that meet the following performance requirements:

.1 Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.

.2 Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG.

.3 Thermal Effects: <+.033 F.S./Deg. F. over 40°F. to 100°F. (calibrated at 70°F.).

.2 Standalone pressure transmitters shall be mounted in a bypass valve assembly panel. The panel shall be constructed to NEMA 1 standards. The transmitter shall be installed in the panel with high and low connections piped and valved. Air bleed units, bypass valves, and compression fittings shall be provided.

.3 Acceptable manufacturers: Johnson Controls and Setra.

.5 Flow Monitoring

.1 Air Flow Monitoring

.1 Fan Inlet Air Flow Measuring Stations

.1 At the inlet of each fan and near the exit of the inlet sound trap, airflow traverse probes shall be provided that shall continuously monitor the fan air volumes and system velocity pressure.

.2 Each traverse probe shall be of a dual manifolded, cylindrical, type 3003 extruded aluminum configuration, having an anodized finish to eliminate surface pitting and unnecessary air friction. The multiple total pressure manifold shall have sensors located along the stagnation plane of the approaching airflow. The manifold should not have forward projecting sensors into the air stream. The static pressure manifold shall incorporate dual offset static tops on the opposing sides of the averaging manifold so as to be insensitive to flow-angle variations of as much as $\pm$ 20° in the approaching air stream.

.3 The airflow traverse probe shall not induce a measurable pressure drop, nor shall the sound level within the duct be amplified by its singular or multiple presence in the air stream. Each airflow-measuring probe shall contain multiple total and static pressure sensors placed at equal distances along the probe length. The number of sensors on each probe and the quantity of probes utilized at each installation shall comply with the ASHRAE Standards for duct traversing.

.4 Airflow measuring stations shall be manufactured by Air Monitor Corp., Tek-Air Systems, Inc., Ebtron, or Dietrich Standard.

.2 Single Probe Air Flow Measuring Sensor

.1 The single probe airflow-measuring sensor shall be duct mounted with an adjustable sensor insertion length of up to eight inches. The transmitter shall produce a 4-20 mA or 0-10 VDC signal linear to air velocity. The sensor shall be a hot wire anemometer and utilize two temperature sensors and a heater element temperature. The other sensor shall measure the downstream air temperature. The temperature differential shall be directly related to airflow velocity.

.3 Duct Air Flow Measuring Stations

.1 Each device shall be designed and built to comply with, and provide results in accordance with, accepted practice as defined for system testing in the ASHRAE Handbook of fundamentals, as well as in the Industrial Ventilation Handbook.

.2 Airflow measuring stations shall be fabricated of 14-gauge galvanized steel welded casing with 90 Deg. connecting flanges in configuration and size equal to that of the duct into which it is mounted. Each station shall be complete with an air directionalizer and parallel cell profile suppressor (3/4" maximum cell) across the entering air stream and mechanically fastened to the casing in such a way to withstand velocities up to 6000 feet per minute. This air directionalizer and parallel cell honeycomb suppressor shall provide 98% free area, equalize the velocity profile, and eliminate turbulent and rotational flow from the air stream prior to the measuring point.

.3 The total pressure measurement side (high side) will be designed and spaced to the Industrial Ventilation Manual 16th Edition, Page 9-5. The self-averaging manifolding will be manufactured of brass and copper components.

.4 The static pressure sensing probes (low side) shall be bullet-nosed shaped, per detailed radius, as illustrated in Industrial Ventilation Manual 16th Edition, Page 9-5.

.5 The main take-off point from both the total pressure and the static pressure manifolds must be symmetrical.

.6 Total and static pressure manifolds shall terminate with external ports for connection to control tubing. An identification label shall be placed on each unit casing, listing model number, size, area, and specified airflow capacity.

.7 Installation Considerations

.1 The maximum allowable pressure loss through the Flow and Static Pressure elements shall not exceed .065" w.c. at 1000 feet per minute, or .23" w.c. at 2000 feet per minute. Each unit shall

measure the airflow rate within an accuracy of plus 2% as determined by U.S. – GSA certification tests, and shall contain a minimum of one total pressure sensor per 36 square inches of unit measuring area.

.2 The units shall have a self-generated sound rating of less than NC40, and the sound level within the duct shall not be amplified nor shall additional sound be generated.

.3 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct. Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

.4 Where control dampers are shown as part of the airflow measuring station, opposed blade precision controlled volume dampers integral to the station and complete with actuator, pilot positioner, and linkage shall be provided.

.5 Stations shall be installed in strict accordance with the manufacturer's published requirements, and in accordance with ASME Guidelines affecting non-standard approach conditions.

.8 Acceptable manufacturers: Air Monitor Corp., Tek-Air, Ebtron, and Dietrich Standard.

.4 Static Pressure Traverse Probe

.1 Duct static traverse probes shall be provided where required to monitor duct static pressure. The probe shall contain multiple static pressure sensors located along exterior surface of the cylindrical probe.

.2 Acceptable manufacturers: Cleveland Controls

.5 Shielded Static Air Probe

.1 A shielded static pressure probe shall be provided at each end of the building. The probe shall have multiple sensing ports, an impulse suppression chamber, and airflow shielding. A suitable probe for indoor and outdoor locations shall be provided.

.2 Water Flow Monitoring

.1 Water flow meters shall be electromagnetic type with integral microprocessor-Based electronics. The meter shall have an accuracy of 0.25%.

.2 Acceptable manufacturers: Onicon

.6 Power Monitoring Devices

.1 Current Measurement (Amps)

.1 Current measurement shall be by a combination current transformer and a current transducer. The current transformer shall be sized to reduce the full amperage of the monitored circuit to a maximum 5 Amp signal, which will be converted to a 4-20 mA DDC compatible signal for use by the Facility Management System.

.2 Current Transformer – A split core current transformer shall be provided to monitor motor amps.

.1 Operating frequency – 50 - 400 Hz.

.2 Insulation – 0.6 Kv class 10Kv BIL.

.3 UL recognized.

.4 Five amp secondary.

.5 Select current ration as appropriate for application.

.6 Acceptable manufacturers: Veris Industries

.3 Current Transducer – A current to voltage or current to mA transducer shall be provided. The current transducer shall include:

.1 6X input over amp rating for AC inrushes of up to 120 amps.

.2 Manufactured to UL 1244.

.3 Accuracy: +.5%, Ripple +1%.

.4 Minimum load resistance 30kOhm.

.5 Input 0-20 Amps.

.6 Output 4-20 mA.

.7 Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).

.8 Acceptable manufacturers: Veris Industries

.7 CO and NO2 Gas Detectors

.1 Gas detection system shall consist of a BACnet controller VA301C/EL/VIP that will supervise the zone CO detectors E3SMSCO and the NO2 detectors E3SMSCO. The BACnet controller will connect to the DDC

.2 Zone detectors required dry contact to start and stop fans directly

.3 Acceptable manufacturers: Honeywell

.8 Smoke Detectors

.1 Ionization type air duct detectors shall be furnished as specified elsewhere in Division 16 for installation under Division 15. All wiring for air duct detectors shall be provided under Division 16, Fire Alarm System.

.9 Status and Safety Switches

.1 General Requirements

.1 Switches shall be provided to monitor equipment status, safety conditions, and generate alarms at the BMS when a failure or abnormal condition occurs. Safety switches shall be provided with two sets of contacts and shall be interlock wired to shut down respective equipment.

.2 Current Sensing Switches

.1 The current sensing switch shall be self-powered with solid-state circuitry and a dry contact output. It shall consist of a current transformer, a solid state current sensing circuit, adjustable trip point, solid state switch, SPDT relay, and an LED indicating the on or off status. A conductor of the load shall be passed through the window of the device. It shall accept over-current up to twice its trip point range.

.2 Current sensing switches shall be used for run status for fans, pumps, and other miscellaneous motor loads.

.3 Current sensing switches shall be calibrated to show a positive run status only when the motor is operating under load. A motor running with a broken belt or coupling shall indicate a negative run status.

.4 Acceptable manufacturers: Veris Industries

.3 Air Filter Status Switches

.1 Differential pressure switches used to monitor air filter status shall be of the automatic reset type with SPDT contacts rated for 2 amps at 120VAC.

.2 A complete installation kit shall be provided, including: static pressure tops, tubing, fittings, and air filters.

.3 Provide appropriate scale range and differential adjustment for intended service.

.4 Acceptable manufacturers: Johnson Controls, Cleveland Controls

.4 Air Flow Switches

.1 Differential pressure flow switches shall be bellows actuated mercury switches or snap acting micro-switches with appropriate scale range and differential adjustment for intended service.

.2 Acceptable manufacturers: Johnson Controls, Cleveland Controls

.5 Air Pressure Safety Switches

.1 Air pressure safety switches shall be of the manual reset type with SPDT contacts rated for 2 amps at 120VAC.

.2 Pressure range shall be adjustable with appropriate scale range and differential adjustment for intended service.

.3 Acceptable manufacturers: Johnson Controls, Cleveland Controls

.6 Water Flow Switches

.1 Water flow switches shall be equal to the Johnson Controls P74.

.7 Low Temperature Limit Switches

.1 The low temperature limit switch shall be of the manual reset type with Double Pole/Single Throw snap acting contacts rated for 16 amps at 120VAC.

.2 The sensing element shall be a minimum of 15 feet in length and shall react to the coldest 18-inch section. Element shall be mounted horizontally across duct in accordance with manufacturers recommended installation procedures.

.3 For large duct areas where the sensing element does not provide full coverage of the air stream, additional switches shall be provided as required to provide full protection of the air stream.

.4 The low temperature limit switch shall be equal to Johnson Controls A70.

2.9 OUTPUT DEVICES

.1 Actuators

.1 General Requirements

.1 Damper and valve actuators shall be electronic and/or pneumatic, as specified in the System Description section.

.2 Electronic Damper Actuators

.1 Electronic damper actuators shall be direct shaft mount.

.2 Modulating and two-position actuators shall be provided as required by the sequence of operations. Damper sections shall be sized Based on actuator manufacturer's recommendations for face velocity, differential pressure and damper type. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the dampers, as required. All actuators (except terminal units) shall be furnished with mechanical spring return unless otherwise specified in the sequences of operations. All actuators shall have external adjustable stops to limit the travel in either direction, and a gear release to allow manual positioning.

.3 Modulating actuators shall accept 24 VAC or VDC power supply, consume no more than 15 VA, and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA, and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal and may be used to parallel other actuators and provide true position indication. The feedback signal of one damper actuator for each separately controlled damper shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

.4 Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Isolation, smoke, exhaust fan, and other dampers, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop associated fan. Two-position actuators, as specified in sequences of operations as "quick acting," shall move full stroke within 20 seconds. All smoke damper actuators shall be quick acting.

.5 Acceptable manufacturers: Johnson Controls, Mamac.

.3 Electronic Valve Actuators

.1 Electronic valve actuators shall be manufactured by the valve manufacturer.

.2 Each actuator shall have current limiting circuitry incorporated in its design to prevent damage to the actuator.

.3 Modulating and two-position actuators shall be provided as required by the sequence of operations. Actuators shall provide the minimum torque required for proper valve close-off against the system pressure for the required application. The valve actuator shall be sized Based on valve manufacturer's recommendations for flow and pressure differential. All actuators shall fail in the last position unless specified with mechanical spring return in the sequence of operations. The spring return feature shall permit normally open or normally closed positions of the valves, as required. All direct shaft mount rotational actuators shall have external adjustable stops to limit the travel in either direction.

.4 Modulating Actuators shall accept 24 VAC or VDC and 120 VAC power supply and be UL listed. The control signal shall be 2-10 VDC or 4-20 mA and the actuator shall provide a clamp position feedback signal of 2-10 VDC. The feedback signal shall be independent of the input signal, and may be used to parallel other actuators and provide true position indication. The feedback signal of each valve actuator (except terminal valves) shall be wired back to a terminal strip in the control panel for trouble-shooting purposes.

.5 Two-position or open/closed actuators shall accept 24 or 120 VAC power supply and be UL listed. Butterfly isolation and other valves, as specified in the sequence of operations, shall be furnished with adjustable end switches to indicate open/closed position or be hard wired to start/stop the associated pump or chiller.

.6 Acceptable manufacturers: Johnson Controls

.2 Control Dampers

.1 The BMS Subcontractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Subcontractor or as specifically indicated on the Drawings.

.2 All dampers used for throttling airflow shall be of the opposed blade type arranged for normally open or normally closed operation, as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop to shift the characteristic curve to near linear.

.3 All dampers used for two-position, open/close control shall be parallel blade type arranged for normally open or closed operation, as required.

.4 Damper frames and blades shall be constructed of either galvanized steel or aluminum. Maximum blade length in any section shall be 60". Damper blades shall be 16-gauge minimum and shall not exceed eight (8) inches in width. Damper

frames shall be 16-gauge minimum hat channel type with corner bracing. All damper bearings shall be made of reinforced nylon, stainless steel or oil-impregnated bronze. Dampers shall be tight closing, low leakage type, with synthetic elastomer seals on the blade edges and flexible stainless steel side seals. Dampers of 48”x48” size shall not leak in excess of 8.0 cfm per square foot when closed against 4” w.g. static pressure when tested in accordance with AMCA Std. 500.

.5 Airfoil blade dampers of double skin construction with linkage out of the air stream shall be used whenever the damper face velocity exceeds 1500 FPM or system pressure exceeds 2.5” w.g., but no more than 4000 FPM or 6” w.g. Acceptable manufacturers are Johnson Controls D-7250 D-1250 or D-1300, Ruskin CD50, and Vent Products 5650.

.6 One piece rolled blade dampers with exposed or concealed linkage may be used with face velocities of 1500 FPM or below. Acceptable manufacturers are: Johnson Controls D-1600, Ruskin CD36, and Vent Products 5800.

.7 Multiple section dampers may be jack-shafted to allow mounting of piston pneumatic actuators and direct connect electronic actuators. Each end of the jackshaft shall receive at least one actuator to reduce jackshaft twist.

.3 Control Relays

.1 Control Pilot Relays

.1 Control pilot relays shall be of a modular plug-in design with retaining springs or clips.

.2 Mounting Bases shall be snap-mount.

.3 DPDT, 3PDT, or 4PDT relays shall be provided, as appropriate for application.

.4 Contacts shall be rated for 10 amps at 120VAC.

.5 Relays shall have an integral indicator light and check button.

.6 Acceptable manufacturers: Johnson Controls, Lectro

.2 Lighting Control Relays

.1 Lighting control relays shall be latching with integral status contacts.

.2 Contacts shall be rated for 20 amps at 277 VAC.

.3 The coil shall be a split low-voltage coil that moves the line voltage contact armature to the ON or OFF latched position.

.4 Lighting control relays shall be controlled by:

.1 Pulsed Tri-state Output – Preferred method.

.2 Pulsed Paired Binary Outputs.

.3 A Binary Input to the Facility Management System shall monitor integral status contacts on the lighting control relay. Relay status contacts shall be of the "dry-contact" type.

.5 The relay shall be designed so that power outages do not result in a change-of-state, and so that multiple same state commands will simply maintain the commanded state. Example: Multiple OFF command pulses shall simply keep the contacts in the OFF position.

.4 Control Valves

.1 All automatic control valves shall be fully proportioning and provide near linear heat transfer control. The valves shall be quiet in operation and fail-safe open, closed, or in their last position. All valves shall operate in sequence with another valve when required by the sequence of operations. All control valves shall be sized by the control manufacturer, and shall be guaranteed to meet the heating and cooling loads, as specified. All control valves shall be suitable for the system flow conditions and close against the differential pressures involved. Body pressure rating and connection type (sweat, screwed, or flanged) shall conform to the pipe schedule elsewhere in this Specification.

.2 Chilled water control valves shall be modulating plug, ball, and/or butterfly, as required by the specific application. Modulating water valves shall be sized per manufacturer's recommendations for the given application. In general, valves (2 or 3-way) serving **variable** flow air handling unit coils shall be sized for a pressure drop equal to the actual coil pressure drop, but no less than 5 PSI. Valves (3-way) serving **constant** flow air handling unit coils with secondary circuit pumps shall be sized for a pressure drop equal to 25% the actual coil pressure drop, but no less than 2 PSI. Mixing valves (3-way) serving secondary water circuits shall be sized for a pressure drop of no less than 5 PSI. Valves for terminal reheat coils shall be sized for a 2 PSIG pressure drop, but no more than a 5 PSI drop.

.3 Ball valves shall be used for hot and chilled water applications, water terminal reheat coils, radiant panels, unit heaters, package air conditioning units, and fan coil units except those described hereinafter.

.4 Modulating plug water valves of the single-seat type with equal percentage flow characteristics shall be used for all special applications as indicated on the valve schedule. Valve discs shall be composition type. Valve stems shall be stainless steel.

.5 Butterfly valves shall be acceptable for modulating large flow applications greater than modulating plug valves, and for all two-position, open/close applications. In-line and/or three-way butterfly valves shall be heavy-duty pattern with a body rating comparable to the pipe rating, replaceable lining suitable for temperature of system,

and a stainless steel vane. Valves for modulating service shall be sized and travel limited to 50 degrees of full open. Valves for isolation service shall be the same as the pipe. Valves in the closed position shall be bubble-tight.

.6 Acceptable manufacturers: Johnson Controls

.5 Electronic Signal Isolation Transducers

.1 A signal isolation transducer shall be provided whenever an analog output signal from the BMS is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input signal from a remote system.

.2 The signal isolation transducer shall provide ground plane isolation between systems.

.3 Signals shall provide optical isolation between systems.

.4 Acceptable manufacturers: Advanced Control Technologies

.6 External Manual Override Stations

.1 External manual override stations shall provide the following:

.1 An integral HAND/OFF/AUTO switch shall override the controlled device pilot relay.

.2 A status input to the Facility Management System shall indicate whenever the switch is not in the automatic position.

.3 A Status LED shall illuminate whenever the output is ON.

.4 An Override LED shall illuminate whenever the HOA switch is in either the HAND or OFF position.

.5 Contacts shall be rated for a minimum of 1 amp at 24 VAC.

.7 Electronic/Pneumatic Transducers

.1 Electronic to Pneumatic transducers shall provide:

.1 Output: 3-15 PSIG.

.2 Input: 4-20 mA or 0-10 VDC.

.3 Manual output adjustment.

.4 Pressure gauge.

.5 External replaceable supply air filter.

.6 Acceptable manufacturers: Johnson Controls, Mamac

2.10 MISCELLANEOUS DEVICES

.1 Variable Frequency Motor Speed Control Drives

.1 All VFD/VSD to have BACnet interface built into the device. If the manufacturer is not able to provide this, get another manufacturer.

.2 Acceptable manufacturers: ABB, Johnson Controls

.2 Local Control Panels

.1 All control panels shall be factory constructed, incorporating the BMS manufacturer's standard designs and layouts. All control panels shall be UL inspected and listed as an assembly and carry a UL 508 label listing compliance. Control panels shall be fully enclosed, with perforated sub-panel, hinged door, and slotted flush latch.

.2 In general, the control panels shall consist of the DDC controller(s), display module as specified and indicated on the plans, and I/O devices—such as relays, transducers, and so forth—that are not required to be located external to the control panel due to function. Where specified the display module shall be flush mounted in the panel face unless otherwise noted.

.3 All I/O connections on the DDC controller shall be provide via removable or fixed screw terminals.

.4 Low and line voltage wiring shall be segregated. All provided terminal strips and wiring shall be UL listed, 300-volt service and provide adequate clearance for field wiring.

.5 All wiring shall be neatly installed in plastic trays or tie-wrapped.

.6 A convenience 120 VAC duplex receptacle shall be provided in each enclosure, fused on/off power switch, and required transformers.

.3 Power Supplies

.1 DC power supplies shall be sized for the connected device load. Total rated load shall not exceed 75% of the rated capacity of the power supply.

.2 Input: 120 VAC +10%, 60Hz.

.3 Output: 24 VDC.

.4 Line Regulation: +0.05% for 10% line change.

.5 Load Regulation: +0.05% for 50% load change.

.6 Ripple and Noise: 1 mV rms, 5 mV peak to peak.

.7 An appropriately sized fuse and fuse block shall be provided and located next to the power supply.

.8 A power disconnect switch shall be provided next to the power supply.

.4 Thermostats

.1 Electric room thermostats of the heavy-duty type shall be provided for unit heaters, cabinet unit heaters, and ventilation fans, where required. All these items shall be provided with concealed adjustment. Finish of covers for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

.2

Part 3 Performance/Execution

3.1 BMS SPECIFIC REQUIREMENTS

.1 Graphic Displays

.1 Provide advanced color graphic system flow diagram display for each system with all points as indicated on the point list. All terminal unit graphic displays shall be from a standard design library.

.2 User shall access the various system schematics via a graphical penetration scheme and/or menu selection. .

.2 Custom Reports:

1. Provide custom reports as specified by the City of Winnipeg:

.3 Actuation / Control Type

.1 Primary Equipment

.1 Controls shall be provided by equipment manufacturer as specified herein.

.2 All damper and valve actuation shall be electric.

.2 Air Handling Equipment

.1 All air handers shall be controlled with a HVAC-DDC Controller

.2 All damper and valve actuation shall be electric.

.3 Terminal Equipment:

.1 Terminal Units (VAV, UV, etc.) shall have electric damper and valve actuation.

.2 All Terminal Units shall be controlled with HVAC-DDC Controller)

3.2 INSTALLATION PRACTICES

.1 BMS Wiring

.1 All conduit, wiring, accessories and wiring connections required for the installation of the Building Management System, as herein specified, shall be provided by the BMS Subcontractor unless specifically shown on the Electrical Drawings under Division 16 Electrical. All wiring shall comply with the requirements of applicable portions of Division 16 and all local and national electric codes, unless specified otherwise in this section.

.2 All BMS wiring materials and installation methods shall comply with BMS manufacturer recommendations.

.3 The sizing, type and provision of cable, conduit, cable trays, and raceways shall be the design responsibility of the BMS Subcontractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Subcontractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

.4 Class 2 Wiring

.1 All Class 2 (24VAC or less) wiring shall be installed in conduit unless otherwise specified.

.2 Conduit is not required for Class 2 wiring in concealed accessible locations. Class 2 wiring not installed in conduit shall be supported every 5’ from the building structure utilizing metal hangers designed for this application. Wiring shall be installed parallel to the building structural lines. All wiring shall be installed in accordance with local code requirements.

.5 Class 2 signal wiring and 24VAC power can be run in the same conduit. Power wiring 120VAC and greater cannot share the same conduit with Class 2 signal wiring.

.6 Provide for complete grounding of all applicable signal and communications cables, panels and equipment so as to ensure system integrity of operation. Ground cabling and conduit at the panel terminations. Avoid grounding loops.

.2 BMS Line Voltage Power Source

.1 120-volt AC circuits used for the Building Management System shall be taken from panel boards and circuit breakers provided by Division 16.

.2 Circuits used for the BMS shall be dedicated to the BMS and shall not be used for any other purposes.

.3 DDC terminal unit controllers may use AC power from motor power circuits.

.3 BMS Raceway

.1 All wiring shall be installed in conduit or raceway except as noted elsewhere in this specification. Minimum control wiring conduit size 1/2".

.2 Where it is not possible to conceal raceways in finished locations, surface raceway (Wiremold) may be used as approved by the Contract Administrator.

.3 All conduits and raceways shall be installed level, plumb, at right angles to the building lines and shall follow the contours of the surface to which they are attached.

.4 Flexible Metal Conduit shall be used for vibration isolation and shall be limited to 3 feet in length when terminating to vibrating equipment. Flexible Metal Conduit may be used within partition walls. Flexible Metal Conduit shall be UL listed.

.4 Penetrations

.1 Provide fire stopping for all penetrations used by dedicated BMS conduits and raceways.

.2 All openings in fire proofed or fire stopped components shall be closed by using approved fire resistive sealant.

.3 All wiring passing through penetrations, including walls shall be in conduit or enclosed raceway.

.4 Penetrations of floor slabs shall be by core drilling. All penetrations shall be plumb, true, and square.

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.5 BMS Identification Standards

.1 Node Identification. All nodes shall be identified by a permanent label fastened to the enclosure. Labels shall be suitable for the node location.

Cable types specified in Item A shall be color coded for easy identification and troubleshooting.

.6 BMS Panel Installation

.1 The BMS panels and cabinets shall be located as indicated at an elevation of not less than 2 feet from the bottom edge of the panel to the finished floor. Each cabinet shall be anchored per the manufacturer's recommendations.

.2 The BMS Subcontractor shall be responsible for coordinating panel locations with other trades and electrical and Mechanical Subcontractors.

.7 Input Devices

.1 All Input devices shall be installed per the manufacturer recommendation

.2 Locate components of the BMS in accessible local control panels wherever possible.

.8 HVAC Input Devices – General

.1 All Input devices shall be installed per the manufacturer recommendation

.2 Locate components of the BMS in accessible local control panels wherever possible.

.3 The Mechanical Subcontractor shall install all in-line devices such as temperature wells, pressure taps, airflow stations, etc.

.4 Input Flow Measuring Devices shall be installed in strict compliance with ASME guidelines affecting non-standard approach conditions.

.5 Outside Air Sensors

.1 Sensors shall be mounted on the North wall to minimize solar radiant heat impact or located in a continuous intake flow adequate to monitor outside air conditions accurately.

.2 Sensors shall be installed with a rain proof, perforated cover.

.6 Water Differential Pressure Sensors

.1 Differential pressure transmitters used for flow measurement shall be sized to the flow-sensing device.

.2 Differential pressure transmitters shall be supplied with tee fittings and shut-off valves in the high and low sensing pick-up lines.

.3 The transmitters shall be installed in an accessible location wherever possible.

.7 Medium to High Differential Water Pressure Applications (Over 21” w.c.):

.1 Air bleed units, bypass valves and compression fittings shall be provided.

.8 Building Differential Air Pressure Applications (-1” to +1” w.c.):

.1 Transmitters exterior sensing tip shall be installed with a shielded static air probe to reduce pressure fluctuations caused by wind.

.2 The interior tip shall be inconspicuous and located as shown on the drawings.

.9 Air Flow Measuring Stations:

.1 Where the stations are installed in insulated ducts, the airflow passage of the station shall be the same size as the inside airflow dimension of the duct.

.2 Station flanges shall be two inch to three inch to facilitate matching connecting ductwork.

.10 Duct Temperature Sensors:

.1 Duct mount sensors shall mount in an electrical box through a hole in the duct and be positioned so as to be easily accessible for repair or replacement.

.2 The sensors shall be insertion type and constructed as a complete assembly including lock nut and mounting plate.

.3 For ductwork greater in any dimension than 48 inches or where air temperature stratification exists such as a mixed air plenum, utilize an averaging sensor.

.4 The sensor shall be mounted to suitable supports using factory approved element holders.

.11 Space Sensors:

.1 Shall be mounted per ADA requirements.

.2 Provide lockable tamper-proof covers in public areas and/or where indicated on the plans.

.12 Low Temperature Limit Switches:

.1 Install on the discharge side of the first water or steam coil in the air stream.

.2 Mount element horizontally across duct in a serpentine pattern insuring each square foot of coil is protected by 1 foot of sensor.

.3 For large duct areas where the sensing element does not provide full coverage of the air stream, provide additional switches as required to provide full protection of the air stream.

.13 Air Differential Pressure Status Switches:

.1 Install with static pressure tips, tubing, fittings, and air filter.

.14 Water Differential Pressure Status Switches:

.1 Install with shut off valves for isolation.

.9 HVAC Output Devices

.1 All output devices shall be installed per the manufacturers recommendation. The Mechanical Subcontractor shall install all in-line devices such as control valves, dampers, airflow stations, pressure wells, etc.

.2 Actuators: All control actuators shall be sized capable of closing against the maximum system shut-off pressure. The actuator shall modulate in a smooth fashion through the entire stroke. When any pneumatic actuator is sequenced with another device, pilot positioners shall be installed to allow for proper sequencing.

.3 Control Dampers: Shall be opposed blade for modulating control of airflow. Parallel blade dampers shall be installed for two position applications.

.4 Control Valves: Shall be sized for proper flow control with equal percentage valve plugs. The maximum pressure drop for water applications shall be 5 PSI. The maximum pressure drop for steam applications shall be 7 PSI.

.5 Electronic Signal Isolation Transducers: Whenever an analog output signal from the Building Management System is to be connected to an external control system as an input (such as a chiller control panel), or is to receive as an input a signal from a remote system, provide a signal isolation transducer. Signal isolation transducer shall provide ground plane isolation between systems. Signals shall provide optical isolation between systems

3.3 TRAINING

.1 The BMS Subcontractor shall provide the following training services:

.1 One day of on-site orientation by a system technician who is fully knowledgeable of the specific installation details of the project. This orientation shall, at a minimum, consist of a review of the project as-built drawings, the BMS software layout and naming conventions, and a walk through of the facility to identify panel and device locations.

3.4 COMMISSIONING

.1 Fully commission all aspects of the Building Management System Work.

.2 Acceptance Check Sheet

.1 Prepare a check sheet that includes all points for all functions of the BMS as indicated on the point list included in this specification.

.2 Submit the check sheet to the Contract Administrator for approval

.3 The Contract Administrator will use the check sheet as the basis for acceptance with the BMS Subcontractor.

.3 VAV box performance verification and documentation:

.1 The BMS Subcontractor shall test each VAV box for operation and correct flow. At each step, after a settling time, box air flows and damper positions will be sampled. Following the tests, a pass/fail report indicating results shall be produced. Possible results are Pass, No change in flow between full open and full close, Reverse operation or Maximum flow not achieved. The report shall be submitted as documentation of the installation.

.2 The BMS Subcontractor shall issue a report based on a sampling of the VAV calculated loop performance metrics. The report shall indicate performance criteria, include the count of conforming and non-conforming boxes, list the non-conforming boxes along with their performance data, and shall also include graphical representations of performance.

.4 Promptly rectify all listed deficiencies and submit to the Contract Administrator that this has been done

3.5 CONTROL SEQUENCES

.1 Fan system controls-general

.1 Following control sequences shall apply to all supply fan systems whether specifically noted in sequence of operation or not.

.2 Where fan systems have outdoor and return air dampers modulated to maintain mixed air, discharge air, or room temperature, provide adjustable (0 - 1 min.) restriction feature to retard opening of O.A. damper on system start up and enable heating source controls to come into control and prevent nuisance tripping of low limit protection controls.

.3 Provide interlocks to ensure system controls energize and associated return and/or exhaust fans run when supply fan runs.

.4 Provide interlocks to ensure auxiliary equipment such as outdoor air dampers, relief air dampers, etc. are shut off and/or closed when supply fan is off.

.5 Provide all fan systems that introduce O.A. with low limit control in discharge air to shut down supply fan and activate local alarm when discharge air temperature drops below 3 deg.C(37 deg.F). Locate low limit in manner that shall protect heating and cooling coils, and at same time not be subject to nuisance tripping.

.6 Provide differential pressure switches across each filter bank to indicate "filter dirty" notification at DDC user workstation.

.7 All VFD/VSD to have BACnet interface built into the device.

.2 Air handling unit (AHU-1)

.1 System is comprised of a central single duct variable air volume air handling unit, including supply fan, filter banks, control dampers, electric heating coil, DX cooling coil and access section. Actuators for control dampers by controls Contractor.

.2 Units shall operate on an occupied/unoccupied schedule as programmed into the dedicated controller.

.3 Provide night setback during unoccupied mode. In unoccupied mode, supply fan shall be cycled with 100% return air to maintain setback space temperature

.4 AHU-1 shall be interlocked with HRV-1. When AHU-1 is shutdown, HRV-1 shall shutdown. AHU-1 dampers shall revert to the closed position.

.5 AHU controls shall take advantage of free cooling with economizer control:

.1 On a call for cooling, with outdoor air temperature below the economizer lockout, outside dampers shall be modulated with return air damper to maintain mixed air temperature. When economizer dampers are at 100% O.A. position, fresh air supply damper from HRV-1 shall close, supply fan in HRV shall modulate slower or turn off, and return air damper shall close.

.2 With the outside temperature above the return air temperature, the dampers will revert to a minimum outdoor air setting to provide ventilation to the space.

.6 HRV-1 shall provide fresh air to AHU-1 during occupied modes. If more fresh air is required based on feedback from the return air CO2 sensor, economizer damper shall modulate open from normal minimum position to maintain CO2 set point of 800 ppm. Economizer damper adjustment shall be limited such that AHU-1 discharge air temperature is maintained.

.7 Provide discharge air reset to optimize supply air temperature. Reset based on the average of two exterior zone temperature sensors.

.1 In heating season, reset supply air temperature to satisfy the average of the space temperature sensors.

.2 Controller shall modulate the heating output of heating coil to maintain discharge air temperature setpoint.

.8 Each filter bank shall have a differential pressure switch to monitor pressure across each bank for filter status.

.9 Unit shall be shutdown from a signal from the fire alarm panel. Dampers shall revert to the shutdown position. The system shall restart automatically when fire alarm is reset.

.10 Remote Relief air damper shall be modulated to maintain building static pressure setpoint.

.11 The following lists the minimum I/O points to be sensed/controlled by the Controller:

.1 Analogue Inputs

.1 Discharge air temperature

.2 Mixed air temperature

.3 Return air temperature (upstream of mixing with HRV air)

.4 Outside air temperature

.5 Return air CO2 level (upstream of mixing with HRV air)

.6 Space static pressure

.2 Analogue Outputs

.1 Outdoor/return dampers

.2 Heating control

.3 Cooling control

.4 Space static pressure setpoint

.5 Relief air damper position

.6 Economizer damper position

.3 Binary Inputs

.1 Low temperature limit switch

.2 Filter status

.3 Supply fan status

.4 Binary Outputs

.1 Supply fan start/stop

.3 Heat recovery ventilator (HRV-1)

.1 The system is comprised of an indoor heat recovery unit, including supply fan, exhaust fan, heat recovery core, and control dampers.

.2 HRV-1 shall operate based on a programmable schedule and/or when commanded on by the user. Heat recovery ventilators HRV-1 shall operate only during occupied modes.

.3 Provide differential pressure switch to monitor pressure across each filter bank. Alarm shall annunciate at respective controller.

.4 Unit shall be shutdown from signal from the fire alarm panel. The system shall restart automatically when fire alarm is reset.

.5 During occupied mode, with economizer locked out, fresh air supply duct control damper from each HRV shall be open, remote return air control damper for each AHU shall be open, economizer damper at each AHU shall be closed.

.6 During occupied mode, with economizer control enabled, fresh air supply duct control damper from each HRV shall remain open, remote return air control damper for each AHU shall modulate towards closed position, economizer damper on each AHU shall modulate open.

.7 During unoccupied mode, fresh air supply duct control damper at each AHU shall be closed, return air control damper at each AHU shall be open, economizer damper at each AHU shall be closed.

.1 In occupied mode as AHU's enter into unoccupied mode, fresh air supply damper from HRV shall close and HRV supply fans shall slow down.

.2 When all AHU's enter into unoccupied mode, HRV shall shut down supply and exhaust fans with all supply and exhaust air dampers closing.

.3 As AHU's enter into occupied mode from unoccupied mode, HRV fans shall turn on and speed up with all supply and exhaust air dampers opening.

.8 The following lists the minimum I/O points to be sensed/controlled by the Controller

.1 Analogue Inputs

.1 HRV fresh air supply (discharge) air temperature

.2 HRV exhaust inlet air temperature

.2 Analogue Outputs

.1 Remote return air dampers for AHU-1.

.2 Remote fresh air dampers from HRV for AHU-1.

.3 Binary Inputs

.1 Supply fan status

.2 Exhaust fan status

.4 Binary Outputs

.1 Supply fan start/stop

.2 Exhaust fan start/stop

.4 Single duct terminal unit (VAV box)

.1 VAV boxes to have digital controller mounted directly to the VAV box actuator. This is to have a digital room thermostat and proportional control on the damper. This controller to use BACnet.

.2 The single duct terminal (digital control) controls air flow rate of conditioned air into an occupied space in response to a control signal temperature sensor to reduce energy consumption and generate quite operation.

.3 Occupied mode: when the zone temperature is between the occupied heating and cooling setpoints, the primary air damper will be at the minimum air flow and there will be no mechanical heating. On a rise in zone temperature above the cooling setpoint, the primary air damper will increase the air flow and there will be no mechanical heating. On a drop in zone temperature below the heating setpoint, the perimeter electric heaters will be used to maintain the zone temperature, the damper is controlled to provide a minimum air flow.

.4 Unoccupied mode:

.1 AHUs On

.1 When in this mode, while the zone temperature is between the unoccupied heating and cooling setpoints, the primary air damper will be at the minimum air flow, there will be no mechanical heating. On a rise in zone temperature above the unoccupied cooling setpoint, the primary air damper will open to increase the air flow, and there will be no mechanical heating. On a drop in zone temperature below the unoccupied heating setpoint, the perimeter electric heaters will be used to maintain the zone temperature, the damper will be at the minimum air flow.

.2 AHUs Off

.1 When in this mode, the primary air damper will remain at the minimum position and there will be no mechanical heating.

.5 Analogue Inputs

.1 Space temperature

.2 Air flow

.3 Damper position

.6 Analogue Outputs

.1 Space Temperature setpoint

.2 Electric Heating control

.3 Damper control

.5 Domestic water booster pump system (P-1 and ET-1)

.1 Domestic water booster pump system shall operate to maintain system pressure between 138-276 Kpa (20-40 Psi) (Site adjustable).

.2 Control package come with booster pump package. The following lists the minimum I/O points to be sensed by the BMS:

.1 Analogue Inputs

.1 System water pressure

.6 Domestic hot water tank control (DHT-1 and 2)

.1 Hot water tank controls are packaged with tank.

.2 Connect remote auxiliary alarm from domestic hot water tanks to DDC system for annunciation Co-ordinate with The City.

.7 Domestic hot water recirculation (P-2)

.1 Domestic hot water recirculation pump shall operate based on a programmable schedule (automatic timer) and/or when commanded on by the user.

.8 Sump pump control (SMP-1 and 2)

.1 Sump pump controls are packaged with pump.

.2 Connect remote ‘High Water Level Alarm’ from sump pit to BMS system.

.9 Air conditioning unit control (AC-1/CU-2)

.1 Air conditioning packaged controls shall cycle/sequence air conditioners to maintain space temperature.

.2 Where air conditioning occurs in a space with perimeter radiation ,provide interlock between radiation control and air conditioning system such that the radiation will be locked out upon request for air conditioning in the space.

.10 Electric baseboard heater control

.1 Each piece of perimeter radiation will be controlled from a DDC thermostat in each area as indicated.

.2 With the space temperature falling below set point, the perimeter radiation will add heat to the space.

.11 Electric unit heater, force flow heater control

.1 Electric unit heaters, and force flow heaters shall be controlled by electric thermostats installed in the rooms.

.12 Outdoor air temperature

.1 An OAT calculated value will be used for all control references. This calculated value will be determined from at least one outdoor air temperature sensor. Any individual OAT sensor that is determined to be in error will not be used in determination of the calculated value

.1 Electrical room circulation fan FAN-1-01 and FAN-1-02

.1 Room thermostat shall cycle circulation fan to remain electrical room temperature.
.2 Provide inputs and outputs to BAS as follow
.1 Analog inputs: room temperature
.2 Binary inputs: circulation fan status
.3 Binary outputs: circulation fan start/off

.13 Network Room circulation fan F-1

.1 Room thermostat shall cycle circulation fan to remain room temperature.

.2 Provide inputs and outputs to BAS as follow

.1 Analog inputs: room temperature

.2 Binary inputs: circulation fan status

.3 Binary outputs: circulation fan start/off

.14 Composter system (COMP-1, 2, and 3)

.1 Follow manufacturer’s recommendation.

Part 1 General

1.1 SCOPE

.1 Ductwork and plenums.

.2 Fasteners.

.3 Sealants.

1.2 DEFINITIONS

.1 Low Pressure: Static pressure in duct less than 500 Pa (2 in WG) and velocities less than 10 m/s (2000 fpm).

.2 Duct sizes shown on plans are inside clear dimensions. For acoustically lined or internally insulated ducts, maintain sizes inside ducts.

1.3 QUALITY ASSURANCE

.1 Ductwork shall meet the requirements of NFPA No. 90A - Air Conditioning and Ventilating Systems; NFPA No. 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems;

.2 Fabricate in accordance with SMACNA duct manuals and ASHRAE handbooks as a minimum where more stringent requirements are not identified in the Contract documents. Straight tap fittings and dovetail joints are not permitted.

.3 Ductwork used on this project shall be clean and free from scale, corrosion and deposits.

.4 All ductwork shall be delivered clean to the Site and maintained in clean condition. Dirty ductwork shall be removed from Site.

1.4 RELATED WORK SPECIFIED IN OTHER SECTIONS

.1 Duct Insulation Section 23 07 13

.2 Ductwork Cleaning Section 23 31 14

.3 Air Duct Accessories Section 23 33 13

1.5 SUBMITTALS

.1 Submit shop drawings of duct fittings for approval, including particulars such as gauge sizes, welds and configurations prior to start of work.

1.6 ALTERNATIVES

.1 Obtain written permission from the Contract Administrator prior to making variations in duct configuration or sizes. Size alternatives using ASHRAE table for circular equivalents of rectangular ducts.

Part 2 Products

2.1 MATERIALS

.1 Ducts: Galvanized steel lock forming quality, having galvanized coating of 380 g/m^2 (0.078 lb/ft^2) for both sides.

.2 Fasteners: Use rivets and bolts throughout; sheet metal screws accepted on low pressure ducts. Weld kitchen exhaust ducts.

.3 Sealant: Water resistant, fire resistive, compatible with mating materials.

.4 Kitchen Hood and Dishwasher Exhaust Ducts: Minimum 1.4 mm (18 gauge) carbon steel or 1.1 mm (20 gauge) Type 304 stainless steel with welded seams and joints.

2.2 FABRICATION

.1 Prior to the fabrication of ductwork, co-ordinate an field measure all ductwork to ensure a complete installation with respect to all other services. Fabricate ductwork from field measurements and not from plans and shop drawings exclusively. Failure to do so will not constitute an extra to the Contract.

Part 3 Execution

3.1 INSTALLATION

.1 Fabricate ductwork from field measurements and not from plans and shop drawings exclusively. Failure to do so will not constitute an extra to the Contract.

.2 Complete metal ducts within themselves with no single partition between ducts. Where width of duct exceeds 450 mm (18”) crossbrace for rigidity. Open corners are not acceptable.

.3 Lap metal ducts in direction of air flow. Hammer down edges and slips to leave smooth duct interior.

.4 Construct tees, bends and elbows with radius of not less than 1-1/2 times width of duct on centre line. Where not possible and where rectangular elbows are specified, provide double wall air foil type turning vanes. Where acoustical lining is provided, provide turning vanes of perforated metal type with fiberglass inside.

.5 Increase duct sizes gradually, not exceeding 15 deg. divergence wherever possible. Maximum divergence upstream of equipment to be 30 deg. and 45 deg. convergence downstream.

.6 Rigidly construct metal ducts with joints mechanically tight, substantially airtight, braced and stiffened so as not to breathe, rattle, vibrate or sag. Caulk duct joints and connections with sealant as ducts are being assembled. Seal seams on fresh air and exhaust ducts watertight with mastic or high velocity duct sealant.

.7 Weld all stainless steel ductwork and ensure a smooth finish on all interiors.

.8 Set plenum doors 150 mm (6") above floor. Arrange door swings so that fan static holds door in closed position.

3.2 DUCT SEALING

.1 All supply, return and exhaust duct joints, longitudinal as well as transverse, shall be sealed using,

.1 Low Pressure Ductwork:

.1 Slip Joints: Apply heavy brush-on high pressure duct sealant. Apply second application after the first application has completely dried out. Where metal clearance exceeds 1.5 mm (16 gauge) use heavy mastic type sealant.

.2 Flanged Joints: Soft elastomer butyl or extruded form of sealant between flanges followed by an application of heavy brush-on high pressure duct sealant.

.3 Other Joints: Heavy mastic type sealant.

.2 Duct tapes as sealing method are not permitted.

.3 Surfaces to receive sealant should be free from oil, dust, dirt, moisture, rust and other substances that inhibit or prevent bonding.

.4 Prior to sealing all ductwork, demonstrate sealing of a section of each type of duct and obtain approval from the Contract Administrator.

.5 Do not insulate any section of the ductwork until it has been inspected and approved of duct sealant application.

3.3 INSTALLATION

.1 Locate ducts with sufficient space around equipment to allow normal operation and maintenance activities.

.2 Coordinate the location of duct access doors.

.3 Provide openings in ductwork where required to accommodate thermometers and controllers. Provide pitot tube openings where required for testing of systems, complete with metal cap with spring device or screw to ensure against air leakage. Where openings are provided in insulated ductwork, install insulation material inside a metal ring.

.4 Interrupt duct linings at fire, balancing, backdraft and smoke dampers so as not to interfere with operation of devices. Provide sheet metal edge protection over linings on both side of damper device.

.5 Shield ductwork from dust and construction material during construction. Clean any ductwork found to be dirty at no extra cost to the Contract.

.6 Protect carbon steel ductwork exposed to weather by painting or coating with suitable weather resistant material.]

.7 Install ducts associated with fans subject to forced vibration with flexible connections immediately adjacent to equipment. Refer to Section 23 05 48, Vibration Controls for HVAC.

.8 Do not use flexible duct to change direction. Provide a minimum of three (3) duct diameters of straight metal duct between box inlet and flexible connector.

.9 Connect diffusers or troffer boots to low pressure ducts with 300 mm (12") maximum stretched length of flexible duct. Hold in place with caulking compound and strap or clamp.

.10 Prove that ductwork is substantially air tight before covering or concealing.

.11 Clean duct systems and force air at high velocity through duct to remove accumulated dust. To obtain sufficient air, clean half the system at a time. Protect equipment which may be harmed by excessive dirt with filters, or bypass during cleaning.

.12 Clean systems with power vacuum machines. Refer to Section 23 31 14, Ductwork Cleaning.

.13 All segmented type elbows shall be spot welded. No adjustable type elbows are allowed.

.14 All ducts crossing walkways shall be offset to run as close as possible to underside of structure above.

.15 Rigidly construct metal ducts with joints mechanically airtight, braced and stiffened so as not to breathe, rattle, vibrate or sag. Caulk all duct joints and connections with sealant as ducts are being installed. Seal seams on fresh air and exhaust ducts watertight with mastic or high velocity duct sealant.

.16 Lap metal ducts in direction of air flow. Hammer down all edges and slips to leave smooth duct interiors.

Part 1 General

1.1 QUALITY ASSURANCE

.1 Firms shall be specialists in this field.

.2 Cleaning Equipment: 5.0 kPa (20 in WG) suction capacity and 12,000 L/s (25,425 cfm) minimum capacity.

Part 2 Products

2.1 MATERIALS

.1 Access Doors: Minimum 450 mm x 350 mm (18" x 14") door, hinge and frame type, positive latching/locking mechanism. Refer to Section 23 33 13, Air Duct Accessories.

Part 3 Execution

3.1 PREPARATION

.1 Isolate items to be cleaned so as not to contaminate unprotected Work.

.2 Equip vacuum equipment with filters.

3.2 INSTALLING ACCESS DOORS

.1 Locate access doors and install as follows:

.1 At 12.0 m (40'-0") intervals in vertical ducts.
.2 Horizontal ducts at intervals of 6 m (20'-0").
.3 At the base of all duct risers.
.4 Both sides of turning vanes in all ducts.
.5 At each fire damper location.
.6 At each side of all coils except where an access is provided.
.7 At all locations of internally duct mounted equipment or devices including balancing dampers, automatic dampers, damper motors, duct mounted smoke detectors and heat detectors, and controls, except where access is provided.

3.3 CLEANING

.1 When the duct systems are completely installed and before any systems are operated, clean all ductwork, plenums, coils, unit heaters, fan coil units and air handling equipment by compressed air and suction equipment.

.2 Cleaning is not required for exhaust ductwork systems that convey air directly to the outside exclusively without recirculation.

.3 Seal all ductwork outlets after ductwork has been cleaned.

.4 Seal all plenums after cleaning.

3.4 INSPECTION

.1 Ductwork cleanliness will be inspected using a periscope built of 75 mm (3”) diameter tube, mirrors and flashlight.

.2 Ductwork found to be dirty shall be re-cleaned at Contractor’s expense.

.3 Ductwork cleanliness shall be inspected by the Contract Administrator.

Part 1 General

1.1 SCOPE

.1 Duct access doors.

.2 Fire dampers.

.3 Fire stop flaps.

.4 Balancing dampers.

.5 Flexible connections.

.6 Backdraft dampers.

1.2 QUALITY ASSURANCE

.1 Fire dampers shall be ULC listed and constructed in accordance with ULC Standard S 112 "Fire Dampers".

.2 Fusible links on fire dampers shall be constructed to ULC Standard S 505.

.3 Demonstrate re-setting of fire dampers to authorities having jurisdiction and The Contract Administrator.

.4 Access doors shall be ULC labelled.

.5 Accessories shall meet the requirements of NFPA 90A, Air Conditioning and Ventilating Systems. Fabricate in accordance with ASHRAE Handbooks and SMACNA Duct Manuals.

.6 Prove all dampers to inspector at job completion.

1.3 SUBMITTALS

.1 Submit shop drawings of factory fabricated assemblies.

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1	Access Doors:	Controlled Air, Nailor, Air-O-Metal, Titus.
.2	Dampers:	Tamco
.3	Fire Dampers:	Controlled Air, Ruskin, EH Price, Nailor.
.4	Flexible Connections:	Thermaflex M-HKE

2.2 DUCT ACCESS DOORS

.1 Fabricate rigid and close-fitting doors of galvanized steel with sealing gaskets and suitable quick fastening locking devices. Duct access panels with screws are not acceptable. Install minimum 25 mm (1") thick insulation with suitable sheet metal cover frame for insulated ductwork.

.2 Fabricated with two butt hinges and two sash locks for sizes up to 450 mm (18"), two hinges and two compression latches with outside and inside handles for sizes up to 600 mm x 1200 mm (24" x 48") and an additional hinge for larger sizes.

2.3 FIRE DAMPERS

.1 Fabricate of galvanized steel or prime coated black steel weighted to close and lock in closed position when released by fusible link.

.2 Fire dampers shall be curtain type with damper blades retained out of air stream in a recess so free area of connecting ductwork is not reduced.

.3 Fusible links shall be set for 71°C (160°F).

2.4 FIRE STOP FLAPS

.1 Fabricate of heat retardant fabric in galvanized or prime coated black steel frame, spring loaded action to close and lock in closed position when released by fusible link.

.2 Blanket shall be retained in a recess so free area of connecting ductwork is not reduced.

.3 Fusible links shall be set for 71°C (160°C).

2.5 SPLITTER DAMPERS

.1 Fabricate splitter dampers of double thickness sheet metal to streamline shape, properly stiffened to avoid vibration.

.2 Fabricate galvanized steel, minimum 1.6 mm (16 gauge), and provide with adjustable rod and locking screw.

.3 On externally insulated ductwork, install operating mechanisms on a steel bridge type mounting base to permit continuity of insulation under the mechanism.

2.6 BALANCING DAMPERS

.1 Fabricate of galvanized steel, minimum 1.6 mm (16 gauge). Full blade-length shafts of hollow square construction with blades rigidly fastened along entire blade length.

.2 Lockable quadrant type operating mechanism with end bearings on accessible rectangular ducts up to 400 mm (16") deep and on accessible round ducts.

.3 Wide pitch screw operating mechanism with crank operator and end bearings on accessible rectangular ducts 425 mm (17") and over in depth and on all inaccessible rectangular and round ducts.

.4 On rectangular ducts up to 275 mm (11") deep construct of single blade (butterfly) type.

.5 On rectangular ducts 300 mm to 400 mm (12" x 16") deep construct of two opposed blades mechanically interlocked with pivots at quarter points.

.6 On rectangular ducts over 425 mm (17") deep construct of multiple opposed blades, mechanically interlocked with blades no greater than 200 mm (8") deep and pivots equally spaced.

.7 On round ducts construct of single blade (butterfly) type. On 500 Pa (2 in WG) class and on all dampers over 300 mm (12") diameter fabricate with full blade-length shaft.

.8 Construct damper blades for medium and high pressure systems to block air passage 70% maximum. Provide complete with locking type handles.

.9 Provide over-ride limiting stops on all operating mechanisms.

.10 Identify the air flow direction and blade rotation and open and close positions on operating mechanism.

.11 On round ductwork, install operating mechanism on a steel mounted base firmly secured to the ductwork.

.12 On externally insulated ductwork, install operating mechanisms on a steel bridge type mounting base to permit continuity of insulation under the mechanism.

2.7 FLEXIBLE CONNECTIONS

.1 Fabricate of ULC approved neoprene coated flameproof glass fabric approximately 150 mm (6") wide tightly crimped into metal edging strip and attached to ducting and equipment by screws or bolts at 150 mm (6") intervals. Flexible connection airtight at 500 Pa (2 in WG).

2.8 BACKDRAFT DAMPERS

.1 Construct of minimum 1.3 mm (18 gauge) galvanized steel channel frame.

.2 Construct of minimum 0.6 mm (26 gauge) aluminum blades, complete with stiffeners along trailing edge. Fabricate single blade dampers for duct sizes to 240 mm (9"), multiblade dampers for ducts greater than 240 mm (9").

.3 Provide full blade-length shafts complete with brass or nylon bearings.

.4 Provide neoprene anti-clatter blade strips on pivot side of blades.

.5 Construct blade connecting linkage of minimum 2.0 mm (14 gauge) aluminum rod with eyelet, pin bearings, and adjustable counter weight to assist blade opening action.

.6 Maximum blade length of 750 mm (30”).

.7 Backdraft damper suitable for 10 m/s (2000 fpm) face velocity.

Part 3 Execution

3.1 APPLICATION

.1 Provide access door minimum 450 mm x 350 mm or 50 mm (18” x 14” or 2”) smaller than duct dimension for cleaning and inspection at positions indicated by drawings and as follows:

.1 At 6.0 m (20’-0”) intervals on all horizontal ducts.
.2 At 12.0 m (40’-0”) intervals in all vertical duct systems.
.3 At the base of all duct risers.
.4 Both sides of turning vanes in all ducts.
.5 At each fire damper location.
.6 At each side of all heating or cooling coils.
.7 At all locations of internally duct mounted devices including automatic dampers, damper motors, duct mounted smoke detectors and heat detectors, and control sensors and devices.

.2 Provide fire dampers at locations shown, where ducts and outlets pass through fire rated components, and where required by authorities having jurisdiction. Fire dampers shall be complete with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.

.3 Coordinate with the Contractor for correct size openings and proper fire guard sleeving for fire damper penetration.

.4 At each point where ducts pass through partitions, the opening around the duct shall be sealed with non-combustible material.

.5 Provide balancing dampers at points on low pressure supply, return and exhaust systems where branches are taken from larger ducts.

.6 Provide balancing dampers on medium and high pressure systems where indicated. Splitter dampers shall not be used on medium and high pressure system.

.7 Install ducts associated with fans and equipment subject to forced vibration with flexible connections, immediately adjacent to equipment and/or where indicated on drawing.

.8 For connections to medium and high pressure fans, install 15 mm (½”) thick neoprene pad over fabric and hold in place with additional metal straps.

.9 All fire dampers and fire stop flaps are to be left in the closed position for balancing Contractor to fix open.

.10 Support ceiling fire stops from the structure above the fire stop and not from air outlets on associated ductwork.

Part 1 General

1.1 SCOPE

.1 Flexible ducts.

1.2 DEFINITIONS

.1 Low Pressure: Static pressure in duct less than 500 Pa (2 in WG) and velocities less than 10 m/s (2000 fpm).

.2 Duct sizes shown on plans are inside clear dimensions. For acoustically lined or internally insulated ducts, maintain sizes inside ducts.

1.3 QUALITY ASSURANCE

.1 Ductwork shall meet the requirements of NFPA No. 90A - Air Conditioning and Ventilating Systems; NFPA No. 90B, Standard for the Installation of Warm Air Heating and Air Conditioning Systems.

.2 Flexible air duct shall conform to NFPA90A and UL181 standard for factory made air duct materials and air duct connectors. Flexible duct shall have a Fire Rating of at least ½ hour as measured by UL Standard.

Part 2 Products

2.1 MATERIALS

.1 Fasteners: Use rivets and bolts throughout; sheet metal screws accepted on low pressure ducts.

.2 Sealant: Water resistant, fire resistive, compatible with mating materials.

.3 Flexible Duct - Low Pressure: Flexible air duct shall be used where shown on drawings. Length of flexible duct shall not exceed 900 mm (36”). Flexible duct shall be polymetric liner banded to a steel wire helix, wrapped with fiberglass insulation and outer fiberglass reinforced metalized vapour barrier jacket. Flexible duct rated for 12 m/s (2360 fpm) velocity and pressure rated for 500 Pa (2 in WG) positive and 500 Pa (2 in WG) negative.

.4 Standard of Acceptance: Thermaflex M-KE

.5 Standards of Acceptance - Un-insulated: - Thermaflex S-TL
- Insulated: Thermaflex M-KC

Part 3 Execution

3.1 DUCT SEALING

.1 All supply, return and exhaust duct joints, longitudinal as well as transverse, shall be sealed using,

.1 Low Pressure Ductwork:

.1 Joints: Heavy mastic type sealant.

.2 Duct tapes as sealing method are not permitted.

.3 Surfaces to receive sealant should be free from oil, dust, dirt, moisture, rust and other substances that inhibit or prevent bonding.

3.2 INSTALLATION

.1 Do not use flexible duct to change direction.

.2 Connect diffusers or troffer boots to low pressure ducts with 900 mm (36”) maximum stretched length of flexible duct. Hold in place with caulking compound and strap or clamp.

.3 Flexible ducts shall be installed as per SMACNA standards.

Part 1 General

1.1 SCOPE

.1 In-line Centrifugal Duct Fans

.2 Axial Fans

.3 Fan Accessories.

.4 Roof Curbs.

1.2 QUALITY ASSURANCE

.1 Conform to AMCA Bulletins regarding construction and testing. Fans shall bear AMCA certified rating seal for performance and sound ratings.

.2 Fans shall bear CSA label.

1.3 SUBMITTALS

.1 Submit with shop drawings acoustical data and fan curves showing fan performance with fan and system operating point plotted on curves.

.2 Comply with the requirements of Section 01 33 00 - Submittals.

1.4 JOB CONDITIONS

.1 Do not operate fans for any purpose, temporary or permanent until ductwork is clean, filters are in place and bearings are lubricated.

1.5 ALTERNATES

.1 Equivalent fan selections shall not increase motor kilowatts, increase rpm, increase noise level, increase tip speed by more than 10%, or increase inlet air velocity by more than 20%, from that of the specified fan.

1.6 RELATED WORK SPECIFIED IN OTHER SECTIONS

.1 Motors Section 23 05 03

.2 Documentation for HVAC Systems Section 23 05 05

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1	Ceiling Fans	:	Envirofan, Leading Edge
.2	In Line Centrifugal Duct Fans	:	Greenheck, Twin City, Loren Cook, ACME, Penn.

2.2 GENERAL

.1 Statically and dynamically balance fans so no objectionable vibration or noise is transmitted to occupied areas of the building.

.2 Provide balanced variable sheaves for motors 11.2 Kw (15 HP) and under and fixed sheave for 15 kW (20 HP) and over.

.3 Fans are to be capable of accommodating static pressure variations of ±10% with no objectionable operating characteristics.

.4 Supply replacement pulleys and sheaves for fans as required to properly balance the systems to design flows at actual job site static pressure conditions. Obtain requirements from balancing agency (Refer to Section 23 05 93, Testing, Adjusting and Balancing for HVAC Systems.)

.5 Provide cross linkage for inlet vanes on double inlet fan.

.6 Size motors for parallel operating fans for non overloading operation with only one fan operating.

.7 External static pressure means external to the fan cabinet and all accessories such as backdraft dampers, mixing boxes, filters and coils, etc. These accessories if supplied as part of the unit are considered as internal losses for fan.

.8 Two speed motors shall have separate winding for each speed.

2.3 CENTRIFUGAL FANS

.1 Fabricate with multi-blade wheels in heavy gauge steel housing reinforced for service encountered.

.2 Provide heavy duty, self-aligning, anti-friction bearings with external lubrication.

.3 Provide where indicated variable inlet vanes complete with linkage and pneumatic operators.

.4 Provide access door and drain connection to scroll.

.5 Unless noted otherwise, centrifugal fans over 425 mm (17”) diameter shall have die formed air foil blades welded to side and back plate.

.6 Provide fan cabinets lined with minimum 25 mm (1”) acoustic insulation, unless noted otherwise elsewhere in the specifications.

2.4 CEILING FANS

.1 UL listed standard 507 with matching UL listed solid state controls.

.2 Motor to be direct drive permanent split capacitor type with permanent sealed ball bearings and built-in self-resetting internal thermal overload protection.

.3 C/W 6 feet galvanized cable, totally enclosed impact resistant fan guard.

Part 3 Execution

3.1 INSTALLATION

.1 Where inlet or outlet is exposed, provide safety screen.

.2 Supply and install sheaves as necessary for final air balancing.

3.2 PRIMING

.1 Prime coat fan wheels and housing factory inside and outside. Prime coating on aluminum parts is not required.

.2 Provide two additional coats of paint on fans handling air downstream of humidifiers.

3.3 PERFORMANCE

.1 Fan performance based on sea level conditions.

Part 1 General

1.1 SCOPE

.1 Basic terminal units.

.2 Pressure independent variable volume regulators complete with damper motor operator.

.3 Sound attenuator.

.4 Heating coils.

1.2 QUALITY ASSURANCE

.1 The terminal units shall be tested and certified in accordance with applicable ARI equipment test codes.

.2 Insulation materials, coatings, vapour barrier facings, tapes and adhesives: Composite fire and smoke hazard rating shall not exceed 25 for flame spread and 50 for smoke developed.

1.3 LABELLING

.1 Label units with capacities as factory adjusted including minimum maximum ratings of volume regulators.

1.4 SUBMITTALS

.1 Include discharge and radiated sound power level schedules with shop drawings, for each of second through sixth octave bands and inlet pressures of 250 Pa (1 in WG) to 1000 Pa (4 in WG).

.2 Provide for inclusion in maintenance manuals, instructions for resetting constant volume regulators.

.3 Comply with Section 01 33 00, Submittals.

1.5 DAMPER OPERATORS

.1 Terminal unit damper operators shall be provided by the controls trade and factory installed by the terminal unit manufacturer.

Part 2 Products

2.1 APPROVED EQUALS

.1 E.H. Price, Nailor, Titus.

2.2 FABRICATION

.1 Fabricate casing from 0.73 mm (24 gauge) galvanized steel. Line casing with 25 mm (1”) thick 0.7 kg (1.5 lb) density minimum, neoprene or vinyl coated fibrous glass

insulation and provide interior sound attenuator baffle. Casing leakage shall not exceed 2% design flow at rated internal pressure.

.2 Fabricate variable volume regulator sub-assembly of extruded aluminum and coated steel frame with extruded aluminum blades and stainless steel springs. Factory set regulator for specified maximum and minimum air volume.

.3 Reset volume with damper operator attached to assembly allowing flow range modulation from maximum to minimum specified.

.4 Provide coils mounted integral with casing as indicated.

.5 Provide unit complete with sound attenuator at discharge of unit.

.6 Provide access doors integral with casing suitable for providing access to regulators**,** proportioning valves, operators and coils.

.7 Operators and control devices shall be provided by the subcontractor and be factory mounted within unit and control lines be brought to outside of unit.

Part 3 Execution

3.1 INSTALLATION

.1 Arrange for suitable ceiling access to units. Provide access doors or locate above easily removable ceiling components.

.2 Install units individually from the structure. Do not support from adjacent ductwork.

.3 Provide a minimum of four inlet diameters of straight duct at inlet of units.

3.2 PERFORMANCE

.1 Noise Criteria: The maximum discharge sound power levels measured immediately after the unit with attenuator shall not exceed the values noted below. These values are based on a 125 Pa (0.5 in WG) pressure drop through the unit. Sound power levels are in db re 10-12 W.

Active Band Center Frequencies (#2)

250	500	1000	2000

.2 The differential static pressure of the unit shall not exceed 30 Pa (0.10 in WG) with inlet velocities of 10 m/s (2000 fpm) or less. With an attenuator but with no other accessories, the static pressure across the assembly with a 10 m/s (2000 fpm) or less inlet velocity shall not exceed 110 Pa (0.45 in WG).

.3 Unit operation shall be independent of inlet static pressure. Flow, (within the adjustable range) shall not vary by more than 5% for inlet static pressures between minimum specified and 1500 Pa (6 in WG).

.4 Volume regulators shall be capable of maintaining minimum set flows within 5% at inlet velocities down to 3 m/s (600 fpm).

.5 Unit coils, where indicated, shall be 1-row minimum, with minimum capacity indicated with 43°C (110°F) entering water, 32°C (90°F) leaving water and minimum air flow capacity.

Part 1 General

1.1 SCOPE

.1 Diffusers.

.2 Grilles and Registers.

.3 Outside Louvers.

.4 Diffuser Boots.

.5 Roof Hoods.

.6 Goosenecks.

1.2 QUALITY ASSURANCE

.1 Air flow tests and sound level measurement shall be made in accordance with applicable ADC equipment test codes, ASHRAE Standards and AMCA Standards.

.2 Unit rating shall be approved by ADC and AMCA.

.3 Manufacturer shall certify catalogued performance and ensure correct application of air outlet types.

.4 Outside louvers shall bear AMCA seal for free area and water penetration.

1.3 JOB CONDITIONS

.1 Review requirements of outlets as to size, finish and type of mounting prior to submitting shop drawings and schedules of outlets.

.2 Positions indicated are approximate only. Check locations of outlets and make necessary adjustments in position to conform with Architectural features, symmetry and lighting arrangement.

1.4 SUBMITTALS

.1 Submit shop drawings with complete catalogue information, materials of construction, dimensions and accessories.

.2 Submit colour selection charts of finishes, for approval prior to fabrication.

.3 Comply with requirements of Section 01 33 00,

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1 Diffusers: : Titus, Price, Nailor.
.2 Grilles and Registers : Titus, Price, Nailor.

.3	Outside Louvres	:	Aerolite, Westvent, Ruskin.
.4	Roof Hoods	:	Greenheck, Penn, Acme, Carnes, Jenn Air, Airolite, Loren Cook, Vent Air.

2.2 GENERAL

.1 Base air outlet application on space noise level of NC 30 maximum.

.2 Provide supply outlets with sponge rubber seal around the edge.

.3 Provide baffles to direct air away from walls, columns or other obstructions within the radius of diffuser operation.

.4 Provide plaster frame for diffusers located in plaster surfaces.

.5 Provide anti-smudge frames or plaques on diffusers located in rough textured surfaces such as acoustical plaster.

.6 Refer to Grille and Diffuser Schedule on drawings.

2.3 ROOF HOODS

.1 Air inlet or exhaust hoods shall have removable hood, curb flange and birdscreen with 15 mm (½") square mesh.

.2 Fabricate of galvanized steel minimum 1.6 mm (16 gauge) base and 1.0 mm (20 gauge) hood or aluminum minimum 1.6 mm (16 gauge) base and 1.3 mm (18 gauge) hood. Provide suitable reinforcing to hood. Louvers shall be storm proof.

.3 Mount unit on minimum 300 mm (12") high curb base with insulation between duct and curb.

.4 Finish in factory prime coat finish.

.5 Hood outlet area shall be minimum twice throat area.

2.4 GOOSENECKS

.1 Fabricate goosenecks of minimum 1.3 mm (18 gauge) galvanized steel.

.2 Mount on minimum 300 mm (12") high curb base where size exceeds 225 mm x 225 mm (9" x 9").

.3 Fabricate to ASHRAE and SMACNA requirements.

Part 3 Execution

3.1 PRIMING

.1 Paint ductwork visible behind air outlets matte black.

Part 1 General

1.1 GENERAL

.1 System Description:

.1 Packaged Heat Recovery Ventilator

.2 Capable of transferring sensible energy

.3 Designed to be used as a standalone ventilation system or as part of an engineered HVAC system

.4 With flat plate, cross flow heat exchanger integral to the unit.

1.2 QUALITY ASSURANCE

.1 Unit shall be constructed to CSA C22.2 standards and carry the mark label of an approved certifying body.

.2 Unit shall undergo 100% functionality testing at the factory prior to shipping.

.3 Heat exchangers shall be certified and currently listed AHRI and shall meet UL 94 flame spread and smoke generation requirements.

1.3 SUBMITTALS

.1 Comply with the requirements of Section 01 33 00 - Submittals.

Part 2 Products

2.1 APPROVED EQUALS

.1 NU-AIR, Greenheck.

2.2 WARRANTY:

.1 Unit shall not be used during construction. Unit shall be stored and handled according to the manufacturer’s instructions.

.2 Unit shall have a 2 year warranty on all parts except the core which has a 15 year warranty. Housing

2.3 EQUIPMENT CONSTRUCTION:

.1 The cabinet shall be double wall construction. 22 Ga galvanized steel inner wall and 22 Ga galvanized steel (0.050 painted white aluminum) outer wall.

.2 The unit shall be insulated with 1” R4 expanded polystyrene.

.3 All serviceable components shall be accessible through a hinged front access panel.

.4 The heat exchanger core shall be easily removable for servicing.

2.4 BLOWERS:

.1 Blowers shall be FC DWDI, dynamically balanced and operate at not more than 1500 rpm. Internal vibration isolation is not required.

.2 Blower housing shall be galvanized steel.

2.5 MOTORS:

.1 Motors shall be continuous duty, permanently lubricated with a service factor of 1.15, matched to the fan load and required voltage and phase.

.2 Motors enclosure shall be Totally Enclosed.

2.6 ELECTRIAL REQUIREMENTS:

.1 The unit shall have a single point power connection within a NEMA4 enclosure with integral non-fused disconnect switch.

.2 The unit shall come c/w 24 VAC control transformer with 200 VA for internal and remote controls.

2.7 FILTRATION:

.1 Unit shall come complete with 2" thick MERV 8 filters.

2.8 HEAT EXCHANGER:

.1 Polypropylene core constructed of flame retardant material and certified and currently listed with AHRI to Standard 1060.

2.9 DEFROST:

.1 Exhaust only defrost - a temperature sensor shuts down the supply fan when the leaving exhaust air is cold enough to freeze condensate. The supply fan remains off until the leaving exhaust air has reached +8C (47 F). The defrost sensor will allow some field adjustment of the initiation temperature.

.2 Timed fan defrost - a temperature sensor shuts down the supply fan when the outside air is cold enough to freeze condensate. The supply fan remains off for a set length of time. The supply fan resumes normal operation for a set length of time and the cycle repeats as long as the outside air temperature is below the set point. Both defrost and run cycles shall be field adjustable via the unit's control.

2.10 ELECTRICAL WORK

.1 All electrical components used are individually CSA and ULC listed.

.2 Unit manufacturer shall completely wire all components to single point for field connection by an Electrical Subcontractor if specified.

.3 Units shipped in sections shall have pre-tagged wiring for quick connection of electrical circuits.

Part 3 Execution

3.1 INSTALLATION

.1 All electrical components used are individually CSA and ULC listed. The unit must be field certified after installation by others.

.2 Lifting lugs, if required, will be welded or bolted on (removable) depending on job requirements.

.3 Follow manufacturer’s installation guidance.

Part 1 General

1.1 SCOPE

.1 Indoor Air Handling Unit.

1.2 QUALITY ASSURANCE

.1 It is the intent of this specification that the manufacturer provide air handling units designed and manufactured specifically to the requirements of this project. Overall dimensions, and configuration are to be as shown on the plans and as described in the specifications. Take responsibility for the engineering and operational integrity of the air handling unit.

.2 Air Handling Units are to be built by a recognized manufacturer of air handling units who maintains a local parts and service agency.

.3 Unit construction shall be as per the construction details included at the end of this section, and as described herein. Electrical installation shall comply with the requirements of Division 26, and the Canadian Electrical Code.

.4 Air flow rates, external static pressures, water flow rates, coil face velocities, filter face velocities, water and air side pressure drops shall be the same or better than specified.

.5 Fans shall be AMCA certified.

.6 Coils shall be ARI certified.

.7 All motors shall be provided with thermal overload protection.

.8 Construction shall comply with Provincial codes and shall have CGA / CSA approval.

.9 All components, paints, and lining shall have a flame spread rating of not over 25 with no evidence of continued progressive combustion and a smoke developed rating no higher than 50 as tested according to AN/ULC – S102.2 Standard Method of Test for Surface Burning Characteristics of Building Materials and assemblies.

.10 Supply replacement pulleys and sheaves for fans as required to properly balance the systems to design flows at actual job site static pressure conditions. Obtain requirements from balancing agency (Refer to Section 23 05 93, Testing, Adjusting and Balancing for HVAC Systems.)

.11 Sealing of all unit casing penetrations made on Site such as for piping, conduit, hanger rods, etc. shall be the responsibility of the Mechanical Subcontractor to the satisfaction of the Air Handling unit manufacturer. Sealing method and components shall be suitable to withstand 1.5 times the working pressure of the unit.

.12 Use the following as selection criteria and supply as specified:

2. air flow rate
3. external static pressure

4. water flow rate.

.13 The following are to be equalled or improved:

1. coil face velocities equalled or lowered
2. filter face velocities equalled or lowered
3. sound power levels equalled or lowered
4. outlet velocities equalled or lowered
5. water pressure drops equalled or lowered
6. water flows equalled or lowered
7. external static pressure equalled or increased without any increase in listed fan motor power requirements

1.3 SUBMITTALS

.1 Shop drawings to include all general information defined by Section 01 33 00 Submitals. Omission of any of the requirements identified in the above referenced section(s) and as specified herein will cause shop drawings to be immediately returned without review.

.2 Submit shop drawing which shall include the following minimum information.

.1 Unit Dimensions: Indicated outside dimensional drawing including service clearances.

.2 Construction details: Submit unit construction drawings for the following components:

.1 Side panels, including connection details
.2 Top panel, including connection details
.3 Floor, including connection details
.4 Doors, hinges, latch, viewing port
.5 Fan, motor and drive, mounting and isolation
.6 Coil section
.7 Pipe and conduit penetration through casing or floor
.8 Drain pan
.9 Damper, linkage and drive construction and mounting
.10 Air blender.

.3 Materials of Construction: Indicate material and gauge of all construction components.

.4 Mass Distribution Drawings: Show point loads, and recommended methods of unit installation and lifting.

.5 Fan Performance Data: Submit fan performance curves as well as performance tables.

.6 Electrical voltages, phase and power requirements.

.7 Air Blenders: Make, model, selection criteria and pressure drop curves.

.8 Coils: Selection criteria indicating air side and fluid side capacities, in and out conditions, velocities, pressure drops and fouling factors. Submit a drawing showing headers, circuiting, arrangement, connection sizes, and materials of construction.

.9 Air Filters: Media, efficiency rating, velocity, pressure drop charts and capacities. Indicate mounting method and arrangement.

.10 Vibration Isolator Shop Drawings.

.11 Table indicating pressure drops through all components of the unit.

.12 Damper Shop Drawings. Outside air dampers shall be insulated and "R" value of the total damper as a unit shall not be less than 2.0 hr-ft^2-^{o}F/Btu.

.13 Detailed composite wiring diagrams showing factory installed wiring, including wiring of the control components.

.14 Sound Levels: Submit sound power levels generated by the air handling unit at the inlet and outlet of the unit and outside the fan section. List for individual octave bands in dB referenced to A rating.

.15 Neoprene lining specification including erosion resistance data.

.16 Variable frequency drive assemblies and motor shop drawings and data. Refer to Section 23 05 03, Electric Motors – 600V or Less and Section 23 05 04, Variable Frequency Drives for HVAC Equipment.

.17 Manufacturer catalogue information for variable frequency drives.

.18 Manufacturer's installation instructions.

1.4 RELATED WORK SPECIFIED IN OTHER SECTIONS

.1 Documentation for HVAC Systems Section 23 05 05

Part 2 Products

2.1 ACCEPTABLE MANUFACTURERS

.1 The following manufacturers are approved for use. No substitutions will be permitted.

.2 Daikin Applied 'Vision' Air Handler shall be the basis of design.

2.2 GENERAL DESCRIPTION

.1 Configuration: Fabricate as detailed on drawings.

.2 Performance: Conform to AHRI 430. See schedules on prints.

.3 Acoustics: Sound power levels (dB) for the unit shall not exceed the specified levels shown on the unit schedule. The manufacturer shall provide the necessary sound treatment to meet these levels if required.

2.3 COMPONENTS

.1 Air handling units shall consist of but not be limited to the following components:

.1 Supply fan
.2 Preheat coil
.3 Cooling coil
.4 Summer prefilter
.5 Winter prefilter frame
.6 Final filter
.7 Motorized outdoor air section complete with separate minimum outdoor air section
.8 Motorized return air section
.9 Air blender
.10 Access sections
.11 Outside Air Damper
.12 Discharge air damper

2.4 UNIT CONSTRUCTION

.1 Fabricate unit with heavy gauge channel posts and panels secured with mechanical fasteners. All panels, access doors, and ship sections shall be sealed with permanently applied bulb-type gasket. Shipped loose gasketing is not allowed.

.2 Panels and access doors shall be constructed as a 2-inch nominal thick; thermal broke double wall assembly, injected with foam insulation with an R-value of not less than R-13.

.3 The inner liner shall be constructed of G90 galvanized steel.

.4 The outer panel shall be constructed of G90 galvanized steel.

.5 The floor plate shall be constructed as specified for the inner liner.

.6 Unit will be furnished with solid inner liners.

.7 Panel deflection shall not exceed L/240 ratio at 125% of design static pressure, maximum 5 inches of positive or 6 inches of negative static pressure. Deflection shall be measured at the panel midpoint.

.8 The casing leakage rate shall not exceed .5 cfm per square foot of cabinet area at 5 inches of positive static pressure or 6 inches of negative static pressure (.0025 m3/s per square meter of cabinet area at 1.24 kPa static pressure).

.9 Module to module field assembly shall be accomplished with an overlapping, full perimeter internal splice joint that is sealed with bulb type gasketing on both mating modules to minimize on-site labor and meet indoor air quality standards.

.10 Access doors shall be flush mounted to cabinetry, with minimum of two six inch long stainless steel piano-type hinges, latch and full size handle assembly. Access doors shall swing outward for unit sections under negative pressure. Access doors on positive pressure sections, shall have a secondary latch to relieve pressure and prevent injury upon access.

.11 The unit base shall be provided by others.

.12 Construct drain pans from stainless steel with cross break and double sloping pitch to drain connection. Provide drain pans under cooling coil section. Drain connection centerline shall be a minimum of 3'' above the base rail to aid in proper condensate trapping. Drain connections that protrude from the base rail are not acceptable. There must be a full 2'' thickness of insulation under drain pan.

2.5 FAN ASSEMBLIES

.1 Acceptable fan assembly shall be a double width, double inlet, class II, belt-drive type housed forward curved fan dynamically balanced as an assembly, as shown in schedule. Maximum fan RPM shall be below first critical fan speed. Fan assemblies shall be dynamically balanced by the manufacturer on all three planes and at all bearing supports. Copper lubrication lines shall be provided and extend from the bearings and attached with grease fittings to the fan base assembly near access door. If not supplied at the factory, Contractor shall mount copper lube lines in the field. Fan and motor shall be mounted internally on a steel base. Provide access to motor, drive, and bearings through hinged access door.

.2 Fan and motor shall be mounted internally on a steel base. Factory mount motor on slide base that can be slid out the side of the unit if removal is required. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry.

2.6 BEARINGS, SHAFTS, AND DRIVES

.1 Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards. The bearings shall be designed for service with an L-50 life of 200,000 hours and shall be a heavy duty pillow block, self-aligning, grease-lubricated ball or spherical roller bearing type.

.2 Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

.3 V-Belt drives shall be cast iron or steel sheaves, dynamically balanced, bored to fit shafts and keyed. Fixed sheaves, matched belts, and drive rated based on motor horsepower. Minimum of 2 belts shall be provided on all fans with 10 HP motors and above. Standard drive service factor minimum shall be 1.1 S.F. for 1/4 HP – 7.5 HP, 1.3 S.F. for 10 HP and larger, calculated based on fan brake horsepower.

2.7 ELECTRICAL

.1 Fan motors shall be manufacturer provided and installed, Open Drip Proof, premium efficiency (meets or exceeds EPAct requirements), 1750 RPM, single speed, 575V / 60HZ / 3P. Complete electrical characteristics for each fan motor shall be as shown in schedule.

.2 The air handler(s) shall be ETL and ETL-Canada listed by Intertek Testing Services, Inc. Units shall conform to bi-national standard ANSI/UL Standard 1995/CSA Standard C22.2 No. 236.

.3 Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclosed terminal lugs in terminal box sized to NFPA 70.

.4 Manufacturer shall provide ASHRAE 90.1 Energy Efficiency equation details for individual equipment to assist Building Engineer for calculating system compliance.

.5 Installing Contractor shall provide GFI receptacle within 25 feet of unit to satisfy National Electrical Code requirements.

.6 All electrical connection components shall be field provided and mounted as shown on project schedule.

2.8 COOLING COILS

.1 Direct expansion refrigerant cooling coil shall be provided. Provide access to coil(s) for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 3" beyond unit casing for ease of installation. Coil connections must be factory sealed with grommets on interior and exterior panel liners to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.

.1 Sweat type copper suction headers shall be provided.

.2 Fins shall have a minimum thickness of 0.0075 inch aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.

.3 Coil tubes shall be 5/8 inch OD seamless copper, 0.020 inch nominal tube wall thickness, expanded into fins on 1 1/2-inch centers, brazed at joints.

.4 Sweat type copper suction connections located at the bottom of the suction headers for gravity oil drainage. Coils shall be uniformly circuited in a counterflow manner for either single circuit, row, face, interlaced, or interlaced face split capacity reduction as shown on unit schedule. Pressure type liquid distributors used. Coils shall be tested with 315 pounds air pressure under warm water, and suitable for 250 psig working pressure.

.5 Coil casing shall be a formed channel frame of galvanized steel.

2.9 ELECTRIC HEATING COILS

.1 General: Electric air handling coils shall be manufactured by Brasch Manufacturing Company, Inc. Voltage, size KW, steps and control voltage shall be scheduled. Three phase heaters shall have balanced phases.

.2 Heaters shall be UL Listed for zero clearance and shall meet all NEC requirements.

.3 Heaters shall be Slip-in or Flanged.

.4 Open coil heating elements shall be 80% nickel and 20% chromium; steps shall be arranged to prevent stratification when operating at less then full capacity. Elements for draw-through air handling units shall be derated to 35 watts per square inch.

.5 Element terminals shall be stainless steel; insulators and bracket bushings shall be nonporous ceramic and securely positioned. Terminals shall be machined crimped to elements.

.6 Frame should be constructed of heavy gauge galvanized steel with galvanized steel brackets, stiffening ribs and gussets spot welded to the frame.

.7 Terminal box shall be spot welded construction with solid, hinged cover, totally enclosed, without louvers or grilles per the UL standard.

.8 Airflow direction shall be scheduled. Heater control panel shall be located on same side of unit as drive on fan.

.9 Safety devices: a disc-type automatic reset thermal cutout shall be furnished for primary overtemperature protection. All safety devices shall be serviceable through the terminal box without removing the heater from the unit.

.10 Wiring Diagrams: a unique wiring diagram shall be furnished for each heater. Diagram shall include recommended supply wire gauges per NEC and fuse sizes. Typical Wiring Diagrams are not acceptable.

.11 Built-in components shall include safety interlocking disconnect switch, disconnecting break magnetic contactors, transformer with primary fusing per UL, pressure type airflow switch set at .05” WC, supplementary circuit fuses per NEC (one set fuses per 48 amp circuit) , and separate load and terminal blocks to accept conductors as shown on the electrical plan

.12 Special Options Available – The following special options are required as scheduled:

.13 Overtemperature Protection

.14 Manual Reset Thermal Cutout operating back-up contactors

.15 Switching Devices and Controls

.16 Pressure Differential Airflow Switch

.17 Door Interlock Switch (to break control circuit)

.18 Manufacturer to provide two year limited

.19 warranty for heating elements; other components to be warranted for one year.

2.10 ACCESS DOORS

.1 Provide hinged man sized access doors. Door construction to be the same as casing each complete with 250 mm x 250 mm (10” x 10”) or 250 mm (10”) diameter round wired

glass viewing window. Provide minimum two (2) ventlock latches per door openable from both sides. Door hinge to be continuous cadmium plated piano hinge with brass pin. Doors to be sealed with automotive type 13 mm (½") closed cell hollow round black gasket with a metal encapsulated reinforced backing that mechanically fastens to the door frame. (Neoprene or foam gaskets are not acceptable). Door sizes to be 750 mm x 1800 mm (30" x 72") or as limited by height of unit. Provide access doors for the following sections. All access doors must swing against the air pressure.

.1 Fan Section
.2 Preheat Coil Section
.3 Cooling Coil Section
.4 Final Filter Section
.5 Summer Prefilter Section
.6 Winter Prefilter Section
.7 Mixing Section
.8 Access Sections

2.11 FINISH

.1 Entire exterior is to be painted with two (2) coats primer paint followed by minimum two (2) coats of exterior application of air dried enamel.

2.12 DRAIN PANS

.1 On units without stacked coils, provide a single fabricated 1.6 mm (16 gauge) Type 304 stainless steel drain pan under cooling coils. On units with stacked coils, provide a separate drain pan under each coil. On all units, provide a secondary drain pan extending under the entire access section downstream of the cooling coil, and the humidifier section. Provide a drain pan to drain the fresh air intake or mixing plenum. Pipe all drains to exterior side of unit.

2.13 FILTERS

.1 Furnish combination filter section with 2-inch pleated MERV 8 flat pre-filter with microbial resistant Intersept coating and 12-inch Varicel SH cartridge 85% efficient (MERV 14) final filter. Provide side loading and removal of filters.

.2 Filter media shall be UL 900 listed, Class I or Class II.

.3 Filter Magnehelic gauge(s) shall be furnished and mounted by others.

2.14 DAMPERS

.1 Low leakage type dampers with hollow blades filled with extruded polyurethane insulation. Damper assembly shall have a thermal insulation value of R 0.35 oC m2/W (2 ft^2hoF/Btu), Tamco 9000 or equal.

.2 Blades shall be minimum 2.75 mm (12 gauge) extruded aluminium. Blades shall be of air foil design, 150 mm (6") wide. Maximum blade length 1200 mm (4'-0").

.3 Damper seals shall be designed for minimum air leakage by means of overlapping seals.

.4 Frames shall be minimum 2.75 mm (12 gauge) extruded aluminum channel with grooved inserts for seal.

.5 Install blade linkage hardware in frame out of air stream.

.6 Arrange linkage and provide an adequate number of damper operators to ensure that the interconnected damper sections operate in unison without binding.

.7 The outdoor, and return dampers shall be integral part of the Air Handling Units and shall be supplied and installed by the Air Handling Unit manufacturer at the factory.

.8 Select outdoor and exhaust dampers at 5 M/s (1000 fpm) face velocity. Select return air damper for pressure drop similar to exhaust damper, ductwork and louvre.

.9 Damper operators shall be supplied by controls Contractor and installed by the Air Handling Unit manufacturer at the factory, in accordance with instructions from controls Contractor. Extend drive and provide mounting bracket to place outdoor air actuators outside air stream. Check unit and room height to ensure adequate space if extended through top of cabinet.

2.15 ADDITIONAL SECTIONS

.1 Mixing box section shall be provided withtop outside air opening and end return air opening with or without parallel low leak airfoil damper blades. Dampers shall be hollow core galvanized steel airfoil blades, fully gasketed and have continuous vinyl seals between damper blades in a galvanized steel frame. Dampers shall have stainless steel jamb seals along end of dampers. Linkage and ABS plastic end caps shall be provided when return and outside air dampers sized for full airflow. Return and outside air dampers of different sizes must be driven separately. Damper Leakage: Leakage rate shall be less than two tenths of one percent leakage at 2 inches static pressure differential. Leakage rate tested in accordance with AMCA Standard 500.

Part 3 Execution

3.1 INSTALLATION

.1 Install in accordance with manufacturer’s Installation & Maintenance instructions.

3.2 ENVIRONMENTAL REQUIREMENTS

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

3.3 ASSEMBLY

.1 Pipe units to permit coil removal.

.2 Any piping or conduit passing through the unit casings must be sealed with rubber grommets and retaining plates to prevent air or water leakage.

.3 Insulate all piping as per Section 23 07 19.

.4 Units are to be Site assembled with each section approximately of equal size. Manufacturer's recommended method of installation and sealing of sections after unit is reassembled must be provided with bid submission.

.5 Rig and set the unit in place. Ensure that spreader bars are used and the unit is protected from the lifting cables.

.6 Entire air handling unit is to be levelled.

.7 Each drain connection shall be provided with a deep seal trap, and all connections piped to drain.

.8 Remove all internal hold-down bolts and shipping fasteners, and install any parts that were shipped loose. Level spring isolators.

.9 Check and re-align all access doors and dampers to ensure smooth operation through the entire range of travel.

.10 Upon start-up, each fan motor is to be checked for fan rotations, and amp draw for each phase.

.11 All belt drives are to be re-adjusted for tension and alignment.

.12 Provide a drain valve on each coil drain fitting, and a vent valve on each coil vent.

.13 Any floor penetrations of the unit are to be thoroughly sealed to ensure the watertightness and integrity of the entire floor of the unit.

.14 Air filter supplier shall conduct a field review to confirm filter installation is in accordance with manufacturer's recommendations. Submit report of findings.

.15 Refer to Unit Schedules for performance.

.16 The Contractor shall review all component sections for damage upon arrival to site, prior to acceptance for unpacking and reassembly. Any damages after unpacking are the responsibility of the Contractor.

.17 Gaskets and/or sealing components are to be supplied by the unit supplier. The reassembly of units shall be reviewed and instructed by supplier, to ensure factory quality reassembly.

.18 Contractor shall be responsible for onsite reassembly and onsite leak-testing of units as specified

3.4 ON SITE ALIGNMENT

.1 A qualified millwright shall confirm alignment of the fans and motors and submit a report for each. A vibration specialist shall perform vibration measurements on each fan/motor assembly at full operating performance. Adjustments in the fan balancing and alignment shall be conducted until the vibration measurements fall within the specified tolerances. Submit a report of the findings.

3.5 AIR HANDLING UNIT SCHEDULE

.1 See Mechanical Drawings for Air Handling Unit Schedule