
COMMON WORK RESULTS FOR HVAC

Part 1

General

1.1

SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00.
- .2 Shop drawings to show:
 - .1 Mounting arrangements.
 - .2 Operating and maintenance clearances.
- .3 Shop drawings and product data accompanied by:
 - .1 Detailed drawings of bases, supports, and anchor bolts.
 - .2 Acoustical sound power data, where applicable.
 - .3 Points of operation on performance curves.
 - .4 Manufacturer to certify current model production.
 - .5 Certification of compliance to applicable codes.
- .4 Closeout Submittals:
 - .1 Provide operation and maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.
 - .2 Operation and maintenance manual approved by, and final copies deposited with, Contract Administrator before final inspection.
 - .3 Operation data to include:
 - .1 Control schematics for systems including environmental controls.
 - .2 Description of systems and their controls.
 - .3 Description of operation of systems at various loads together with reset schedules and seasonal variances.
 - .4 Operation instruction for systems and component.
 - .5 Description of actions to be taken in event of equipment failure.
 - .6 Valves schedule and flow diagram.
 - .7 Colour coding chart.
 - .4 Maintenance data to include:
 - .1 Servicing, maintenance, operation and trouble-shooting instructions for each item of equipment.
 - .2 Data to include schedules of tasks, frequency, tools required and task time.
 - .5 Performance data to include:
 - .1 Equipment manufacturer's performance datasheets with point of operation as left after commissioning is complete.
 - .2 Equipment performance verification test results.
 - .3 Special performance data as specified.
 - .4 Testing, adjusting and balancing reports as specified in Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

COMMON WORK RESULTS FOR HVAC

- .6 Approvals:
 - .1 Submit 1 copies of draft Operation and Maintenance Manual to Contract Administrator for approval. Submission of individual data will not be accepted unless directed by Contract Administrator.
 - .2 Make changes as required and re-submit as directed by Contract Administrator.
- .7 Additional data:
 - .1 Prepare and insert into operation and maintenance manual additional data when need for it becomes apparent during specified demonstrations and instructions.
- .8 Site records:
 - .1 Contract Administrator will provide 1 set of reproducible mechanical drawings. Provide sets of white prints as required for each phase of work. Mark changes as work progresses and as changes occur.
 - .2 Transfer information weekly to reproducibles, revising reproducibles to show work as actually installed.
 - .3 Use different colour waterproof ink for each service.
 - .4 Make available for reference purposes and inspection.
- .9 As-built drawings:
 - .1 Prior to start of Testing, Adjusting and Balancing for HVAC, finalize production of as-built drawings.
 - .2 Identify each drawing in lower right hand corner in letters at least 12 mm high as follows: - "AS BUILT DRAWINGS: THIS DRAWING HAS BEEN REVISED TO SHOW MECHANICAL SYSTEMS AS INSTALLED" (Signature of Contractor) (Date).
 - .3 Submit to Contract Administrator for approval and make corrections as directed.
 - .4 Perform testing, adjusting and balancing for HVAC using as-built drawings.
 - .5 Submit completed reproducible as-built drawings with Operating and Maintenance Manuals.
- .10 Submit copies of as-built drawings for inclusion in final TAB report.

1.2 MAINTENANCE

- .1 Provide one set of special tools required to service equipment as recommended by manufacturers and in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Furnish one commercial quality grease gun, grease and adapters to suit different types of grease and grease fittings.

COMMON WORK RESULTS FOR HVAC

Part 2 Products (Not Used)

Part 3 Execution

3.1 PAINTING REPAIRS AND RESTORATION

- .1 Prime and touch up marred finished paintwork to match original.
- .2 Restore to new condition, finishes which have been damaged.

3.2 CLEANING

- .1 Clean interior and exterior of all systems. Vacuum interior of ductwork and air handling units.

3.3 FIELD QUALITY CONTROL

- .1 Manufacturer's Field Services:
 - .1 Obtain written report from manufacturer verifying compliance of Work, in handling, installing, applying, protecting and cleaning of product and submit Manufacturer's Field Reports as described in PART 1 - SUBMITTALS.
 - .2 Provide manufacturer's field services consisting of product use recommendations and periodic site visits for inspection of product installation in accordance with manufacturer's instructions.

3.4 DEMONSTRATION

- .1 Contract Administrator will use equipment and systems for test purposes prior to acceptance. Supply labour, material, and instruments required for testing.
- .2 Supply tools, equipment and personnel to demonstrate and instruct operating and maintenance personnel in operating, controlling, adjusting, trouble-shooting and servicing of all systems and equipment during regular work hours, prior to acceptance.
- .3 Use operation and maintenance manual, as-built drawings, and audio visual aids as part of instruction materials.
- .4 Instruction duration time requirements as specified in appropriate sections.
- .5 Contract Administrator will record these demonstrations on video tape for future reference.

3.5 PROTECTION

- .1 Protect equipment and systems openings from dirt, dust, and other foreign materials with materials appropriate to system.

END OF SECTION

USE OF HVAC SYSTEMS DURING CONSTRUCTION

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Use of mechanical systems during construction.
 - .2 Use of new and/or existing permanent heating and ventilating systems for supplying temporary heat or ventilation is permitted only under following conditions:
 - .1 Entire system is complete, pressure tested, cleaned, flushed out.
 - .2 Building has been closed in, areas to be heated/ventilated are clean and will not thereafter be subjected to dust-producing processes.
 - .3 There is no possibility of damage.
 - .4 Supply ventilation systems are protected by 60% filters, inspected daily, changed every week or more frequently as required.
 - .5 Return systems have approved filters over openings, inlets, outlets.
 - .6 Systems will be:
 - .1 Operated as per manufacturer's recommendations and instructions.
 - .2 Operated by Contractor.
 - .3 Monitored continuously by Contractor.
 - .7 Warranties and guarantees are not relaxed.
 - .8 Regular preventive and other manufacturers recommended maintenance routines are performed by Contractor at own expense and under supervision of Contract Administrator.
 - .9 Refurbish entire system before static completion; clean internally and externally, restore to "as- new" condition, replace filters in air systems.
 - .3 Filters specified in this Section are over and above those specified in other Sections of this project.
 - .4 Exhaust systems are not included in approvals for temporary heating ventilation.

Part 2 Products

2.1 NOT USED

Part 3 Execution

3.1 NOT USED

END OF SECTION

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Electrical motors, drives and guards for mechanical equipment and systems.
 - .2 Supplier and installer responsibility indicated in Motor, Control and Equipment Schedule on electrical drawings and related mechanical responsibility is indicated on Mechanical Equipment Schedule on mechanical drawings.
 - .3 Control wiring and conduit is specified in Division 26 except for conduit, wiring and connections below 50 V which are related to control systems specified in Division 22 and 23. Refer to Division 26 for quality of materials and workmanship.
 - .4 Sustainable requirements for construction and verification.

1.2 REFERENCES

- .1 American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE)
 - .1 ASHRAE 90.1-[01], Energy Standard for Buildings Except Low-Rise Residential Buildings (IESNA cosponsored; ANSI approved; Continuous Maintenance Standard).
- .2 Electrical Equipment Manufacturers' Association Council (EEMAC)
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.
- .3 Closeout Submittals
 - .1 Provide maintenance data for motors, drives and guards for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

Part 2

Products

2.1 GENERAL

- .1 Motors: high efficiency, in accordance with local Hydro company standards and to ASHRAE 90.1.

2.2 MOTORS

- .1 Provide motors for mechanical equipment as specified.
- .2 Motors under 373 W (1/2 HP): speed as indicated, continuous duty, built-in overload protection, resilient mount, single phase, 120 V, unless otherwise specified or indicated.
- .3 Motors 373 W (1/2 HP) and larger: EEMAC Class B, squirrel cage induction, speed as indicated, continuous duty, drip proof, ball bearing, maximum temperature rise 40 degrees C, 3 phase, unless otherwise indicated.

2.3 TEMPORARY MOTORS

- .1 If delivery of specified motor will delay completion or commissioning work, install motor approved by Contract Administrator for temporary use. Work will only be accepted when specified motor is installed.

2.4 BELT DRIVES

- .1 Fit reinforced belts in sheave matched to drive. Multiple belts to be matched sets.
- .2 Use cast iron or steel sheaves secured to shafts with removable keys unless otherwise indicated.
- .3 For motors under 7.5 kW (10 HP): standard adjustable pitch drive sheaves, having plus or minus 10% range. Use mid-position of range for specified r/min.
- .4 For motors 7.5 kW (10 HP) and over: sheave with split tapered bushing and keyway having fixed pitch unless specifically required for item concerned. Provide sheave of correct size to suit balancing.
- .5 Correct size of sheave determined during commissioning.
- .6 Minimum drive rating: 1.5 times nameplate rating on motor. Keep overhung loads within manufacturer's design requirements on prime mover shafts.
- .7 Motor slide rail adjustment plates to allow for centre line adjustment.
- .8 Supply one set of spare belts for each set installed in accordance with Section 01 78 00 - Closeout Submittals.

COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

2.5 DRIVE GUARDS

- .1 Provide guards for unprotected drives.
- .2 Guards for belt drives;
 - .1 Expanded metal screen welded to steel frame.
 - .2 Minimum 1.2 mm thick sheet metal tops and bottoms.
 - .3 38 mm dia holes on both shaft centres for insertion of tachometer.
 - .4 Removable for servicing.
- .3 Provide means to permit lubrication and use of test instruments with guards in place.
- .4 Install belt guards to allow movement of motors for adjusting belt tension.-
- .5 Guard for flexible coupling:
 - .1 "U" shaped, minimum 1.6 mm thick galvanized mild steel.
 - .2 Securely fasten in place.
 - .3 Removable for servicing.
- .6 Unprotected fan inlets or outlets:
 - .1 Wire or expanded metal screen, galvanized, 19 mm mesh.
 - .2 Net free area of guard: not less than 80% of fan openings.
 - .3 Securely fasten in place.
 - .4 Removable for servicing.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Fasten securely in place.
- .2 Make removable for servicing, easily returned into, and positively in position.

3.3 CLEANING

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

THERMOMETERS AND PRESSURE GAUGES - PIPING SYSTEMS

Part 1 General

1.1 SECTION INCLUDES

- .1 Materials and installation for thermometers and pressure gauges in piping systems.

1.2 REFERENCES

- .1 American Society of Mechanical Engineers (ASME).
 - .1 ASME B40.100-[01], Pressure Gauges and Gauge Attachments.
 - .2 ASME B40.200-[01], Thermometers, Direct Reading and Remote Reading.
- .2 Canadian General Standards Board (CGSB).
 - .1 CAN/CGSB-14.4-[M88], Thermometers, Liquid-in-Glass, Self Indicating, Commercial/Industrial Type.
 - .2 CAN/CGSB-14.5-[M88], Thermometers, Bimetallic, Self-Indicating, Commercial/Industrial Type.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit shop drawings and product data.
- .3 Submit manufacturer's product data for following items:
 - .1 Thermometers.
 - .2 Pressure gauges.
 - .3 Stop cocks.
 - .4 Syphons.
 - .5 Wells.

Part 2 Products

2.1 GENERAL

- .1 Design point to be at mid point of scale or range.
- .2 Ranges: as indicated.

2.2 DIRECT READING THERMOMETERS

- .1 Industrial, variable angle type, liquid filled, 125 mm scale length: to CAN/CGSB14.4.

2.3 REMOTE READING THERMOMETERS

- .1 100 mm diameter mercury-free liquid filled vapour activated dial type: to CAN/CGSB-14.5, accuracy within one scale division, brass movement, stainless steel capillary, stainless steel spiral armour, stainless steel bulb and polished stainless steel case for wall mounting.

THERMOMETERS AND PRESSURE GAUGES - PIPING SYSTEMS

2.4 THERMOMETER WELLS

- .1 Copper pipe: copper or bronze.
- .2 Steel pipe: brass or stainless steel.

2.5 PRESSURE GAUGES

- .1 112 mm, dial type: to ASME B40.100, Grade 2A, stainless steel bourdon tube having 0.5% accuracy full scale unless otherwise specified.
- .2 Provide:
 - .1 Siphon for steam service.
 - .2 Snubber for pulsating operation.
 - .3 Diaphragm assembly for corrosive service.
 - .4 Gasketed pressure relief back with solid front.
 - .5 Bronze stop cock.
 - .6 Oil filled for high vibration applications.

Part 3 Execution

3.1 GENERAL

- .1 Install so they can be easily read from floor or platform. If this cannot be accomplished, install remote reading units.
- .2 Install between equipment and first fitting or valve.

3.2 THERMOMETERS

- .1 Install in wells on piping. Provide heat conductive material inside well.
- .2 Install in locations as indicated.
- .3 Use extensions where thermometers are installed through insulation.

3.3 PRESSURE GAUGES

- .1 Install in following locations:
 - .1 Suction and discharge of pumps.
 - .2 Outlet of boilers.
 - .3 In other locations as indicated.
- .2 Install gauge cocks for balancing purposes, elsewhere.
- .3 Use extensions where pressure gauges are installed through insulation.

3.4 NAMEPLATES

- .1 Install engraved lamicoid nameplates as specified in Section 23 05 54 - Mechanical Identification, identifying medium.

END OF SECTION

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Concrete housekeeping pads, hangers and supports for mechanical piping, ducting and equipment.

1.2 REFERENCES

- .1 American National Standards Institute/American Society of Mechanical Engineers (ANSI/ASME)
 - .1 ANSI/ASME B31.1-04, Power Piping.
- .2 American Society for Testing and Materials International (ASTM)
 - .1 ASTM A125-1996(R2001), Specification for Steel Springs, Helical, Heat-Treated.
 - .2 ASTM A307-04, Specification for Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength.
 - .3 ASTM A563-04a, Specification for Carbon and Alloy Steel Nuts.
- .3 Factory Mutual (FM)
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).
- .5 Manufacturer's Standardization Society of the Valves and Fittings Industry (MSS)
 - .1 MSS SP58-2002, Pipe Hangers and Supports - Materials, Design and Manufacture.
 - .2 ANSI/MSS SP69-2003, Pipe Hangers and Supports - Selection and Application.
 - .3 MSS SP89-2003, Pipe Hangers and Supports - Fabrication and Installation Practices.
- .6 Underwriter's Laboratories of Canada (ULC)

1.3 SYSTEM DESCRIPTION

- .1 Design Requirements:
 - .1 Construct pipe hanger and support to manufacturer's recommendations utilizing manufacturer's regular production components, parts and assemblies.
 - .2 Base maximum load ratings on allowable stresses prescribed by ASME B31.1 or MSS SP58.
 - .3 Ensure that supports, guides, anchors do not transmit excessive quantities of heat to building structure.

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

- .4 Design hangers and supports to support systems under conditions of operation, allow free expansion and contraction, prevent excessive stresses from being introduced into pipework or connected equipment.
- .5 Provide for vertical adjustments after erection and during commissioning. Amount of adjustment in accordance with MSS SP58.

1.4 SUBMITTALS

- .1 Submittals: in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit shop drawings and product data for following items:
 - .1 Bases, hangers and supports.
 - .2 Connections to equipment and structure.
 - .3 Structural assemblies.
- .3 Closeout Submittals:
 - .1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.5 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

Part 2 Products

2.1 GENERAL

- .1 Fabricate hangers, supports and sway braces in accordance with ANSI B31.1 and MSS SP58.
- .2 Use components for intended design purpose only. Do not use for rigging or erection purposes.

2.2 PIPE HANGERS

- .1 Finishes:
 - .1 Pipe hangers and supports: galvanized.
 - .2 Use electro-plating galvanizing process or hot dipped galvanizing process.
 - .3 Ensure steel hangers in contact with copper piping are copper plated.
- .2 Upper attachment structural: suspension from lower flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: malleable iron C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip.
 - .1 Rod: 9 mm UL listed.

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

- .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron beam clamp, eye rod, jaws and extension with carbon steel retaining clip, tie rod, nuts and washers, UL listed to MSS-SP58 and MSS-SP69.
- .3 Upper attachment structural: suspension from upper flange of I-Beam:
 - .1 Cold piping NPS 2 maximum: ductile iron top-of-beam C-clamp with hardened steel cup point setscrew, locknut and carbon steel retaining clip, UL listed to MSS SP69.
 - .2 Cold piping NPS 2 1/2 or greater, hot piping: malleable iron top-of-beam jaw-clamp with hooked rod, spring washer, plain washer and nut UL listed.
- .4 Upper attachment to concrete:
 - .1 Ceiling: carbon steel welded eye rod, clevis plate, clevis pin and cotters with weldless forged steel eye nut. Ensure eye 6 mm minimum greater than rod diameter.
 - .2 Concrete inserts: wedge shaped body with knockout protector plate UL listed to MSS SP69.
- .5 Hanger rods: threaded rod material to MSS SP58:
 - .1 Ensure that hanger rods are subject to tensile loading only.
 - .2 Provide linkages where lateral or axial movement of pipework is anticipated.
- .6 Pipe attachments: material to MSS SP58:
 - .1 Attachments for steel piping: carbon steel galvanized.
 - .2 Attachments for copper piping: copper plated black steel.
 - .3 Use insulation shields for hot pipework.
 - .4 Oversize pipe hangers and supports.
- .7 Adjustable clevis: material to MSS SP69 UL listed, clevis bolt with nipple spacer and vertical adjustment nuts above and below clevis.
- .8 Yoke style pipe roll: carbon steel yoke, rod and nuts with cast iron roll, to MSS SP69.
- .9 U-bolts: carbon steel to MSS SP69 with 2 nuts at each end to ASTM A563.
 - .1 Finishes for steel pipework: galvanized.
 - .2 Finishes for copper, glass, brass or aluminum pipework: galvanized, with formed portion plastic coated.
- .10 Pipe rollers: cast iron roll and roll stand with carbon steel rod to MSS SP69.

2.3 RISER CLAMPS

- .1 Steel or cast iron pipe: galvanized carbon steel to MSS SP58, type 42, UL listed.
- .2 Copper pipe: carbon steel copper plated to MSS SP58, type 42.

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

.3 Bolts: to ASTM A307.

.4 Nuts: to ASTM A563.

2.4 INSULATION PROTECTION SHIELDS

.1 Insulated cold piping:

.1 64 kg/m³ density insulation plus insulation protection shield to: MSS SP69, galvanized sheet carbon steel. Length designed for maximum 3 m span.

.2 Insulated hot piping:

.1 Curved plate 300 mm long, with edges turned up, welded-in centre plate for pipe sizes NPS 12 and over, carbon steel to comply with MSS SP69.

2.5 CONSTANT SUPPORT 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, loaded height and provided with Certified Mill Test Report (CMTR).

.2 Load adjustability: 10 % minimum adjustability each side of calibrated load. Adjustment without special tools. Adjustments not to affect travel capabilities.

.3 Provide upper and lower factory set travel stops.

.4 Provide load adjustment scale for field adjustments.

.5 Total travel to be actual travel + 20%. Difference between total travel and actual travel 25 mm minimum.

.6 Individually calibrated scales on each side of support calibrated prior to shipment, complete with calibration record.

2.6 EQUIPMENT ANCHOR BOLTS AND TEMPLATES

.1 Provide templates to ensure accurate location of anchor bolts.

2.7 HOUSE-KEEPING PADS

.1 Provide 100 mm high concrete housekeeping pads for base-mounted equipment; size pads 50 mm larger than equipment; chamfer pad edges.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

.1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

3.2 INSTALLATION

- .1 Install in accordance with:
 - .1 manufacturer's instructions and recommendations.
- .2 Vibration Control Devices:
 - .1 Install on piping systems at pumps, boilers, chillers, cooling towers, and as indicated.
- .3 Clamps on riser piping:
 - .1 Support independent of connected horizontal pipework using riser clamps and riser clamp lugs welded to riser.
 - .2 Bolt-tightening torques to industry standards.
 - .3 Steel pipes: install below coupling or shear lugs welded to pipe.
 - .4 Cast iron pipes: install below joint.
- .4 Clevis plates:
 - .1 Attach to concrete with 4 minimum concrete inserts, one at each corner.
- .5 Provide supplementary structural steelwork where structural bearings do not exist or where concrete inserts are not in correct locations.
- .6 Use approved constant support type hangers where:
 - .1 vertical movement of pipework is 13 mm or more,
 - .2 transfer of load to adjacent hangers or connected equipment is not permitted.
- .7 Use variable support spring hangers where:
 - .1 transfer of load to adjacent piping or to connected equipment is not critical.
 - .2 variation in supporting effect does not exceed 25 % of total load.

3.3 HANGER SPACING

- .1 Fire protection: to applicable fire code.
- .2 Gas and fuel oil piping: up to NPS 1/2: every 1.8 m.
- .3 Copper piping: up to NPS 1/2: every 1.5 m.
- .4 Flexible joint roll groove pipe: in accordance with table below, but not less than one hanger at joints.
- .5 Within 300 mm of each elbow.

Maximum Pipe Size : NPS	Maximum Spacing Steel	Maximum Spacing Copper
up to 1-1/4	2.1 m	1.8 m
1-1/2	2.7 m	2.4 m
2	3.0 m	2.7 m
2-1/2	3.6 m	3.0 m

HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

Maximum Pipe Size : NPS	Maximum Spacing Steel	Maximum Spacing Copper
3	3.6 m	3.0 m
3-1/2	3.9 m	3.3 m
4	4.2 m	3.6 m
5	4.8 m	
6	5.1 m	
8	5.7 m	
10	6.6 m	
12	6.9 m	

- .6 Pipework greater than NPS 12: to MSS SP69.

3.4 HANGER INSTALLATION

- .1 Install hanger so that rod is vertical under operating conditions.
- .2 Adjust hangers to equalize load.
- .3 Support from structural members. Where structural bearing does not exist or inserts are not in suitable locations, provide supplementary structural steel members.

3.5 HORIZONTAL MOVEMENT

- .1 Angularity of rod hanger resulting from horizontal movement of pipework from cold to hot position not to exceed 4 degrees from vertical.
- .2 Where horizontal pipe movement is less than 13 mm, offset pipe hanger and support so that rod hanger is vertical in the hot position.

3.6 FINAL ADJUSTMENT

- .1 Adjust hangers and supports:
 - .1 Ensure that rod is vertical under operating conditions.
 - .2 Equalize loads.
- .2 Adjustable clevis:
 - .1 Tighten hanger load nut securely to ensure proper hanger performance.
 - .2 Tighten upper nut after adjustment.
- .3 C-clamps:
 - .1 Follow manufacturer's recommended written instructions and torque values when tightening C-clamps to bottom flange of beam.
- .4 Beam clamps:
 - .1 Hammer jaw firmly against underside of beam.

END OF SECTION

MECHANICAL IDENTIFICATION

1.1 SUMMARY

- .1 Section Includes:
 - .1 Materials and requirements for the identification of piping systems, duct work, valves and controllers, including the installation and location of identification systems.

1.2 REFERENCES

- .1 Canadian Gas Association (CGA)
 - .1 CSA/CGA B149.1-05, 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.
- .3 National Fire Protection Association (NFPA)
 - .1 NFPA 13-2002, Standard for the Installation of Sprinkler Systems.
 - .2 NFPA 14-2003, Standard for the Installation of Standpipe and Hose Systems.

1.3 SUBMITTALS

- .1 Product Data:
- .2 Submittals: in accordance with section 013300.
- .3 Product data to include paint colour chips, other products specified in this section.

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 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).

MECHANICAL IDENTIFICATION

- .2 Construction:
 - .1 3 mm thick laminated plastic, 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.

2.3 EXISTING IDENTIFICATION SYSTEMS

- .1 Apply existing identification system to new work.
- .2 Before starting work, obtain written approval of identification system from Contract Administrator.

2.4 IDENTIFICATION DUCTWORK SYSTEMS

- .1 50 mm high stencilled letters and directional arrows 150 mm long x 50 mm high.
- .2 Colours: back, or co-ordinated with base colour to ensure strong contrast.

2.5 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 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions,

MECHANICAL IDENTIFICATION

and datasheet.

3.2 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.

3.3 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, and dampers. Where this is not possible, place identification as close as possible, preferably on upstream side.

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

.1 Position of identification 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.

END OF SECTION

TESTING, ADJUSTING AND BALANCING FOR HVAC

Part 1 General

1.1 SUMMARY

- .1 TAB is used throughout this Section to describe the process, methods and requirements of testing, adjusting and balancing for HVAC.
- .2 TAB means to test, adjust and balance to perform in accordance with requirements of Contract Documents and to do other work as specified in this section.
- .3 TAB following air systems:
 - .1 AHU-1, AHU-2 and associated ductwork.
 - .2 Exhaust fans EF-2 and EF-4.
- .4 TAB following water systems:
 - .1 Pump PU-1, PU-2 and associated piping system. Balance flows to AHU-1 and AHU-2.

1.2 QUALIFICATIONS OF TAB PERSONNEL

- .1 Submit names of personnel to perform TAB to Contract Administrator within 90 days of award of contract.
- .2 Provide documentation confirming qualifications, successful experience.
- .3 TAB: performed in accordance with the requirements of standard under which TAB Firm's qualifications are approved:
 - .1 Associated Air Balance Council, (AABC) National Standards for Total System Balance, MN-1-2002.
- .4 Recommendations and suggested practices contained in the TAB Standard: mandatory.
- .5 Use TAB Standard provisions, including checklists, and report forms to satisfy Contract requirements.
- .6 Use TAB Standard for TAB, including qualifications for TAB Firm and Specialist and calibration of TAB instruments.
- .7 Where instrument manufacturer calibration recommendations are more stringent than those listed in TAB Standard, use manufacturer's recommendations.
- .8 TAB Standard quality assurance provisions such as performance guarantees form part of this contract.
 - .1 For systems or system components not covered in TAB Standard, use TAB procedures developed by TAB Specialist.

TESTING, ADJUSTING AND BALANCING FOR HVAC

- .2 Where new procedures, and requirements, are applicable to Contract requirements have been published or adopted by body responsible for TAB Standard used (AABC, NEBB, or TABB), requirements and recommendations contained in these procedures and requirements are mandatory.

1.3 PURPOSE OF TAB

- .1 Test to verify proper and safe operation, determine actual point of performance, evaluate qualitative and quantitative performance of equipment, systems and controls at design, average and low loads using actual or simulated loads
- .2 Adjust and regulate equipment and systems to meet specified performance requirements and to achieve specified interaction with other related systems under normal and emergency loads and operating conditions.
- .3 Balance systems and equipment to regulate flow rates to match load requirements over full operating ranges.

1.4 EXCEPTIONS

- .1 TAB of systems and equipment regulated by codes, standards to satisfaction of authority having jurisdiction.

1.5 CO-ORDINATION

- .1 Schedule time required for TAB (including repairs, re-testing) into project construction and completion schedule to ensure completion before acceptance of project.
- .2 Do TAB of each system independently and subsequently, where interlocked with other systems, in unison with those systems.

1.6 PRE-TAB REVIEW

- .1 Review contract documents before project construction is started and confirm in writing to Contract Administrator adequacy of provisions for TAB and other aspects of design and installation pertinent to success of TAB.
- .2 Review specified standards and report to Contract Administrator in writing proposed procedures which vary from standard.
- .3 During construction, co-ordinate location and installation of TAB devices, equipment, accessories, measurement ports and fittings.

1.7 START-UP

- .1 Follow start-up procedures as recommended by equipment manufacturer unless specified otherwise.
- .2 Follow special start-up procedures specified elsewhere in Division 23.

TESTING, ADJUSTING AND BALANCING FOR HVAC

1.8 OPERATION OF SYSTEMS DURING TAB

- .1 Operate systems for length of time required for TAB and as required by Contract Administrator for verification of TAB reports.

1.9 START OF TAB

- .1 Notify Contract Administrator 7 days prior to start of TAB.
- .2 Start TAB when building is essentially completed, including:
- .3 Installation of ceilings, doors, windows, other construction affecting TAB.
- .4 Application of weatherstripping, sealing, and caulking.
- .5 Pressure, leakage, other tests specified elsewhere Division 23.
- .6 Provisions for TAB installed and operational.
- .7 Start-up, verification for proper, normal and safe operation of mechanical and associated electrical and control systems affecting TAB including but not limited to:
 - .1 Proper thermal overload protection in place for electrical equipment.
 - .2 Air systems:
 - .1 Filters in place, clean.
 - .2 Duct systems clean.
 - .3 Ducts, air shafts, ceiling plenums are airtight to within specified tolerances.
 - .4 Correct fan rotation.
 - .5 Fire, smoke, volume control dampers installed and open.
 - .6 Coil fins combed, clean.
 - .7 Access doors, installed, closed.
 - .8 Outlets installed, volume control dampers open.
 - .3 Liquid systems:
 - .1 Flushed, filled, vented.
 - .2 Correct pump rotation.
 - .3 Strainers in place, baskets clean.
 - .4 Isolating and balancing valves installed, open.
 - .5 Calibrated balancing valves installed, at factory settings.
 - .6 Chemical treatment systems complete, operational.

1.10 APPLICATION TOLERANCES

- .1 Do TAB to following tolerances of design values:
 - .1 HVAC systems: plus 5%, minus 5%.
 - .2 Hydronic systems: plus or minus 10%.

TESTING, ADJUSTING AND BALANCING FOR HVAC

1.11 ACCURACY TOLERANCES

- .1 Measured values accurate to within plus or minus 2% of actual values.

1.12 INSTRUMENTS

- .1 Prior to TAB, submit to Contract Administrator list of instruments used together with serial numbers.
- .2 Calibrate in accordance with requirements of most stringent of referenced standard for either applicable system or HVAC system.
- .3 Calibrate within 3 months of TAB. Provide certificate of calibration to Contract Administrator.

1.13 SUBMITTALS

- .1 Submit, prior to commencement of TAB:
- .2 Proposed methodology and procedures for performing TAB if different from referenced standard.

1.14 PRELIMINARY TAB REPORT

- .1 Submit for checking and approval of Contract Administrator, prior to submission of formal TAB report, sample of rough TAB sheets. Include:
 - .1 Details of instruments used.
 - .2 Details of TAB procedures employed.
 - .3 Calculations procedures.
 - .4 Summaries.

1.15 TAB REPORT

- .1 Format in accordance with referenced standard.
- .2 TAB report to show results in SI units and to include:
 - .1 Project record drawings.
 - .2 System schematics.
- .3 Submit 6 copies of TAB Report to Contract Administrator for verification and approval, in D-ring binders, complete with index tabs.

1.16 VERIFICATION

- .1 Reported results subject to verification by Contract Administrator.
- .2 Provide personnel and instrumentation to verify up to 30% of reported results.
- .3 Number and location of verified results as directed by Contract Administrator.

TESTING, ADJUSTING AND BALANCING FOR HVAC

- .4 Pay costs to repeat TAB as required to satisfaction of Contract Administrator.

1.17 SETTINGS

- .1 After TAB is completed to satisfaction of Contract Administrator, replace drive guards, close access doors, lock devices in set positions, ensure sensors are at required settings.
- .2 Permanently mark settings to allow restoration at any time during life of facility. Do not eradicate or cover markings.

1.18 COMPLETION OF TAB

- .1 TAB considered complete when final TAB Report received and approved by Contract Administrator.

1.19 AIR SYSTEMS

- .1 Standard: TAB to most stringent of this section or TAB standards of AABC.
 - .1 Do TAB of systems, equipment, components, controls specified Division 23.
- .2 Qualifications: personnel performing TAB current member in good standing of AABC.
- .3 Quality assurance: perform TAB under direction of supervisor qualified by AABC.
- .4 Measurements: to include as appropriate for systems, equipment, components, controls: air velocity, static pressure, flow rate, pressure drop (or loss), temperatures (dry bulb, wet bulb, dewpoint), duct cross-sectional area, RPM, electrical power, voltage, noise, vibration.
- .5 Locations of equipment measurements: to include as appropriate:
 - .1 Inlet and outlet of dampers, filter, coil, humidifier, fan, other equipment causing changes in conditions.
 - .2 At controllers, controlled device.
- .6 Locations of systems measurements to include as appropriate: main ducts, main branch, sub-branch, run-out (or grille, register or diffuser).

Part 2 Products

2.1 NOT USED

- .1 Not used.

Part 3 Execution

3.1 NOT USED

- .1 Not used.

END OF SECTION

THERMAL INSULATION FOR PIPING

Part 1 General

1.1 SUMMARY

.1 Section Includes:

.1 Insulation of the following piping:

- .1 New hydronic piping, including heat exchanger.
- .2 New refrigerant piping.

1.2 REFERENCES

- .1 CAN/CGSB-51.9-92, Mineral Fibre Thermal Insulation for Piping and Round Ducting
- .2 CGSB 51-GP-52Ma-89, Vapour Barrier Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.

1.3 SUBMITTALS

.1 Product Data:

.1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

1.4 DEFINITIONS:

.1 For purposes of this section:

- .1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
- .2 "EXPOSED" - will mean "not concealed" as defined herein.
- .3 Insulation systems - insulation material, fasteners, jackets, etc.

Part 2 Products

2.1 GENERAL

- .1 Components of insulation system to have maximum flame spread rating of 25 and maximum smoke developed rating of 50 in accordance with CAN/ULC-S102.
- .2 Materials to be tested in accordance with ASTM C411.

2.2 P-1 FORMED MINERAL FIBER TO 200°C

.1 Applications: new glycol piping.

.2 Materials:

.1 Rigid, one piece fibreglass pipe insulation with all service jacket of high density white kraft bonded to aluminum foil. Provide all weather protective jacket for outdoor installation.

THERMAL INSULATION FOR PIPING

- .2 Acceptable materials: Schuller, Micro-lok, Knauf.

FLUID TEMPERATURE (C)	NOMINAL PIPE SIZES			
	25 mm and Under	32 to 50 mm	63 to 100 mm	125 mm and Over
5 – 29	25 mm	25 mm	25 mm	25 mm
30 – 49	25 mm	25 mm	25 mm	25 mm
50- 90	50 mm	50 mm	25 mm	25 mm

- .3 Thermal Conductivity "k" shall not exceed 0.034 W/m.°C at 24°C mean temperature when tested in accordance with ASTM C335.
- .4 For refrigerant piping: 25 mm thick flexible closed cell insulation Armaflex or equal.
- .5 Outdoor piping: 38 mm thick.

2.3 FASTENINGS

- .1 For insulation systems P-1:
- .1 Tape: self adhesive, ULC labelled for less than 25 flame spread and less than 50 smoke developed.
- .2 Lap seal adhesive: quick-setting for joints and lap sealing of vapour barriers.
- .3 Lagging adhesive: fire retardant coating.

2.4 INSULATION CEMENT

- .1 To CAN/CGSB-51.12.

2.5 JACKETS

- .1 Canvas cover

Part 3 Execution

3.1 APPLICATION

- .1 Apply insulation after required tests have been completed and approved by Contract Administrator.
- .2 Surfaces shall be warm, clean and dry during application of insulation and finishes.
- .3 Apply insulation materials, accessories and finishes in accordance with manufacturer's recommendations and as specified herein.
- .4 On piping with insulation and vapour barrier, install high density insulation under hanger shield. Maintain integrity of vapour barrier over full length of pipe without interruption at sleeves, fittings and supports.

THERMAL INSULATION FOR PIPING

3.2 INSTALLATION

- .1 Install in accordance with ANSI/NFPA 90A and ANSI/NFPA 90B.
- .2 Seal and finish exposed ends and other terminations with insulating cement.
- .3 Flanges and unions at equipment, valves, other components requiring regular maintenance: omit insulation and bevel away from studs and nuts to permit use of tools without damage to insulation.

3.3 FASTENINGS

- .1 Secure pipe insulation by tape at each end and centre of each section, but not greater than 900 mm on centres.

END OF SECTION

THERMAL INSULATION FOR DUCTING

Part 1 General

1.1 REFERENCES

- .1 American Society of Heating, Refrigeration and Air Conditioning Engineers (ASHRAE)
 - .1 ANSI/ASHRAE/IESNA 90.1-01, SI; Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 American Society for Testing and Materials International, (ASTM)
 - .1 ASTM B209M-02, Specification for Aluminum and Aluminum Alloy Sheet and Plate (Metric).
 - .2 ASTM C335-95, Test Method for Steady State Heat Transfer Properties of Horizontal Pipe Insulation.
 - .3 ASTM C411-97, Test Method for Hot-Surface Performance of High-Temperature Thermal Insulation.
 - .4 ASTM C449/C449M-00, Standard Specification for Mineral Fiber-Hydraulic-Setting Thermal Insulating and Finishing Cement.
 - .5 ASTM C547-00, Specification for Mineral Fiber Pipe Insulation.
 - .6 ASTM C553-00, Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
 - .7 ASTM C612-00a, Specification for Mineral Fiber Block and Board Thermal Insulation.
 - .8 ASTM C795-92, Specification for Thermal Insulation for Use with Austenitic Stainless Steel.
 - .9 ASTM C921-92(1998)e1, Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- .3 Canadian General Standards Board (CGSB)
 - .1 CGSB 51-GP-52Ma-89, Vapour Barrier, Jacket and Facing Material for Pipe, Duct and Equipment Thermal Insulation.
- .4 Thermal Insulation Association of Canada (TIAC): National Insulation Standards (R1999).
- .5 Underwriters Laboratories of Canada (ULC)
 - .1 CAN/ULC-S102-M88(R2000), Surface Burning Characteristics of Building Materials and Assemblies.
 - .2 CAN/ULC-S701-01, Thermal Insulation Polyotrene, Boards and Pipe Covering.

1.2 DEFINITIONS

- .1 For purposes of this section:
 - .1 "CONCEALED" - insulated mechanical services and equipment in suspended ceilings and non-accessible chases and furred-in spaces.
 - .2 "EXPOSED" - will mean "not concealed" as defined herein.

THERMAL INSULATION FOR DUCTING

- .3 Insulation systems - insulation material, fasteners, jackets, and other accessories.
- .2 TIAC Codes:
 - .1 CRD: Code Round Ductwork,
 - .2 CRF: Code Rectangular Finish.
- 1.3 SHOP DRAWINGS**
 - .1 Submit shop drawings in accordance with section 013300.
 - .2 Submit for approval manufacturer's catalogue literature related to installation, fabrication for duct jointing recommendations.
- 1.4 MANUFACTURERS' INSTRUCTIONS**
 - .1 Submit manufacturer's installation instructions in accordance with section 013300.
 - .2 Installation instructions to include procedures used, and installation standards achieved.
- 1.5 QUALIFICATIONS**
 - .1 Installer: specialist in performing work of this section, and have at least 3 years successful experience in this size and type of project, qualified to standards.
- 1.6 DELIVERY, STORAGE AND HANDLING**
 - .1 Deliver materials to site in original factory packaging, labelled with manufacturer's name, address.
 - .2 Protect from weather and construction traffic.
 - .3 Protect against damage from any source.
 - .4 Store at temperatures and conditions recommended by manufacturer.
- Part 2 Products**
 - 2.1 FIRE AND SMOKE RATING**
 - .1 In accordance with CAN/ULC-S102:
 - .1 Maximum flame spread rating: 25.
 - .2 Maximum smoke developed rating: 50.
 - 2.2 INSULATION**
 - .1 Mineral fibre: as specified includes glass fibre, rock wool, slag wool.
 - .2 Thermal conductivity ("k" factor) not to exceed specified values at 24°C mean temperature when tested in accordance with ASTM C335.

THERMAL INSULATION FOR DUCTING

- .3 TIAC Code C-1: Rigid mineral fibre board to ASTM C612, with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this Section).
- .4 TIAC Code C-2: Mineral fibre blanket to ASTM C553 faced with factory applied vapour retarder jacket to CGSB 51-GP-52Ma (as scheduled in PART 3 of this section).
 - .1 Mineral fibre: to ASTM C553.
 - .2 Jacket: to CGSB 51-GP-52Ma.
 - .3 Maximum "k" factor: to ASTM C553.

2.3 JACKETS

- .1 Aluminum:
 - .1 To ASTM B209 with moisture barrier as scheduled in PART 3 of this section.
 - .2 Thickness: 0.50 mm sheet.
 - .3 Finish: Stucco embossed.
 - .4 Jacket banding and mechanical seals: 12 mm wide, 0.5 mm thick stainless steel.

2.4 ACCESSORIES

- .1 Vapour retarder lap adhesive:
 - .1 Water based, fire retardant type, compatible with insulation.
- .2 Indoor Vapour Retarder Finish:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
- .3 Insulating Cement: hydraulic setting on mineral wool, to ASTM C449.
- .4 ULC Listed Canvas Jacket:
 - .1 220 gm/m² cotton, plain weave, treated with dilute fire retardant lagging adhesive to ASTM C921.
- .5 Outdoor Vapour Retarder Mastic:
 - .1 Vinyl emulsion type acrylic, compatible with insulation.
 - .2 Reinforcing fabric: Fibrous glass, untreated 305 g/m².
- .6 Tape: self-adhesive, aluminium, reinforced, 75 mm wide minimum.
- .7 Contact adhesive: quick-setting
- .8 Canvas adhesive: washable.
- .9 Tie wire: 1.5 mm stainless steel.
- .10 Banding: 12 mm wide, 0.5 mm thick stainless steel.

THERMAL INSULATION FOR DUCTING

- .11 Fasteners: 4 mm diameter pins with 35 mm diameter clips, length to suit thickness of insulation.

Part 3 Execution

3.1 PRE-INSTALLATION REQUIREMENTS

- .1 Pressure testing of ductwork systems complete, witnessed and certified.
- .2 Surfaces clean, dry, free from foreign material.

3.2 INSTALLATION

- .1 Install in accordance with TIAC National Standards.
- .2 Apply materials in accordance with manufacturers instructions and as indicated.
- .3 Use two layers with staggered joints when required nominal thickness exceeds 75 mm.
- .4 Maintain uninterrupted continuity and integrity of vapour retarder jacket and finishes.
 - .1 Hangers, supports to be outside vapour retarder jacket.
- .5 Supports, Hangers in accordance with Section 23 31 14 - Metal Ducts - Low Pressure To 500 Pa.
 - .1 Apply high compressive strength insulation where insulation may be compressed by weight of ductwork.
- .6 Fasteners: At 300 mm oc in horizontal and vertical directions, minimum two rows each side.

3.3 DUCTWORK INSULATION SCHEDULE

- .1 Insulation types and thicknesses: Conform to following table:

	TIAC Code	Vapour Retarder	Thickness (mm)
Rectangular cold and dual temperature supply air ducts	C-1	Yes	25
Round cold and dual temperature supply air ducts	C-2	Yes	25
Exhaust duct between fan and louvers	C-1	No	50

END OF SECTION

CONTROL SYSTEM FOR HVAC

Part 1 General

1.1 General and Related Work

- .1 All work of this Division shall be coordinated and provided by the single Building Management System (BMS) Contractor.
- .2 If the Contractor believes there are conflicts or missing information in the Contract Documents then the Contractor shall promptly request clarification and instruction from the Contract Administrator before proceeding.
- .3 No LON protocols are accepted.
- .4 The 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 using Microsoft Visio software.
- .5 The Contractor to provide commissioning sheets for all points on field devices as well as head end equipment.
- .6 The Contractor shall meet with City of Winnipeg Tech Shop staff to go over naming conventions, graphics, alarms etc. at the start of project. Controller addresses to be coordinated with the Tech Shop.
- .7 The work of this Division shall be scheduled, coordinated, and interfaced with the associated work of other trades. Reference the Mechanical Division Sections for details.
- .8 The Contractor shall have visited the Project Site and obtained information as necessary prior to submittal of the bid to ensure that prevailing physical conditions and Project arrangements that may be material to the performance of the Work have been ascertained and accommodated in the bid. No claims for additional payments will be accepted due to the Contractor's failure to complete this survey.
- .9 If, in order to complete the Work of the Controls Contract, private and/or public telephone lines and connections, including ISDN lines and/or LAN/WAN support and connections, are required then these shall be provided by the City to the Contractor, at the City's direct cost, in a timely manner.
- .10 There is an existing central monitoring system in place. The Contractor shall visit the City of Winnipeg tech shop for a walk through of the existing controls prior to bid closing date. Where DDC points are identified as centrally monitored points, the Contractor shall provide and install required hardware and software to interface to the existing Johnson Controls Metasys EA servers and workstations. These are located at the Central Control Offices, 510 Main Street, Winnipeg, Manitoba.
- .11 This facility has existing Johnson Controls DDC systems using N2 open communication bus technology. Where required, and identified in this specification, the Contractor is to provide a web server (NAE/NCE) with N2 open bus(s) to interface existing systems to allow monitoring of these systems, per paragraph .F above.
- .12 Control Systems Description

CONTROL SYSTEM FOR HVAC

- .1 The Building Management System (BMS) shall be a complete system designed for use with the enterprise IT systems in place at the City of Winnipeg. 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 Contract Administrator's IT staff to ensure that the FMS will perform in the Contract Administrator's environment without disruption to any of the other activities taking place on that LAN.
- .2 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.
- .3 Where necessary and as dictated elsewhere in these Specifications, the City of Winnipeg's existing ADX Server 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.
- .4 The work of the single BMS Contractor shall be as defined individually and collectively in all Sections of this Division specification together with the associated Point Sheets and Drawings and the associated interfacing work as referenced in the related documents.
- .5 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.
- .6 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.
- .7 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.
- .8 The Controls System as provided shall comprise, at a minimum, the following primary elements:
 1. NAE/NCE Web server(s).
 2. Network and application nodes.
 3. Field devices.
 4. Control wiring.
- .13 Quality Assurance

CONTROL SYSTEM FOR HVAC

.1 Workplace Safety And Hazardous Materials

1. Provide a safety program in compliance with the Contract Documents.
2. The FMS Contractor 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 sub contractors 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 General Contractor or the Contract Administrator 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.

.14 Submittals

.1 Shop Drawings, Product Data, and Samples

1. The BMS contractor 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 Contractor where filing is necessary. Provide a copy of all related correspondence and permits to the Contract Administrator.

CONTROL SYSTEM FOR HVAC

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 Contractor shall correct any errors or omissions noted in the first review.
7. 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.
- .15 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.

CONTROL SYSTEM FOR HVAC

- .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.
 - 3. All drawings and graphics must come in a Visio format.
- .16 Warranty
- .1 Standard Material and Labor Warranty:
 - 1. Provide a one-year labor and material warranty, starting from the date of Substantial Performance, on the BMS.
 - 2. If within twelve (12) months from the date of acceptance of product, upon written notice from the Contract Administrator, it is found to be defective in operation, workmanship or materials, it shall be replaced, repaired or adjusted at the option of the BMS Contractor at the cost of the BMS Contractor.

Part 2 Products

- .1 Control System Architecture
 - .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 the existing networks.
 - .2 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.
 - .3 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.
- .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.

CONTROL SYSTEM FOR HVAC

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) and Network Control Engines (NCE) 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.
 6. The Contract Administrator shall provide all private and public telephones lines, ISDN lines and Internet Service Provider services and connections as necessary for the Contractor to complete the work as contracted at the Contract Administrator's direct cost. The Contractor shall identify the specific requirements in their shop drawing submittal.
- .2 Control Network
1. NAE(s) and NCE(s) 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 The Johnson Controls N2 Field Bus.
 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, or Johnson Controls N2 Field Bus.
 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.
- .3 Integration (if required)
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.

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- .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.
- .3 Network Automation Engines (NAE)
- .1 Network Automation Engine (**NAEXX**)
- 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.

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- .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:
 - ◇ Configuration
 - ◇ Commissioning
 - ◇ Data Archiving
 - ◇ Monitoring
 - ◇ Commanding
 - ◇ 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

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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.
 - ◇ 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.
 - ◇ The Conformance Statements shall be submitted 10 day prior to bidding.
 - ◇ The NAE shall support a minimum of 32 control devices.
 - .2 The NAE shall support the Johnson Controls N2 Field Bus.
 - ◇ The NAE shall support a minimum of 32 N2 control devices.
 - ◇ The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
 - ◇ The Bus shall employ a master/slave protocol where the NAE is the master.
 - ◇ The Bus shall employ a four (4) level priority system for polling frequency.
 - ◇ The Bus shall be optically isolated from the NAE.
 - ◇ The Bus shall support the Metasys Integrator System.
- 4 Network Control Engine (NCE 25XX)
1. The Network Control Engine (NCE) shall be a fully user-programmable, supervisory controller. The NCE 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. The Network Control Engine (NCE) shall be a fully user-programmable, digital controller that includes a minimum of 33 I/O points.

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3. Automation Network – The NCE shall reside on the automation network and shall support a subnet of 32 Field controllers.
4. User Interface – Each NCE 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 NCE. Systems that require a local copy of the system database on the user's personal computer are not acceptable.
 - .2 The NCE shall support a minimum of two (2) concurrent users.
 - .3 The NCE shall have the capability of generating web based UI graphics. The graphics capability shall be imbedded in the NCE.
 - .4 Systems that support UI Graphics from a central database or require the graphics to reside on the user's personal computer are not acceptable.
 - .5 The web based UI shall support the following functions using a standard version of Microsoft Internet Explorer:
 - ◇ Configuration
 - ◇ Commissioning
 - ◇ Data Archiving
 - ◇ Monitoring
 - ◇ Commanding
 - ◇ System Diagnostics
 - .6 Systems that require workstation software or modified web browsers are not acceptable.
 - .7 The NCE shall allow temporary use of portable devices without interrupting the normal operation of permanently connected modems.
5. The NCE 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.
6. The NCE 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.
7. The NCE shall be assembled in a plenum-rated plastic housing with flammability rated to UL94-5VB.
8. The NCE shall support the following number and types of inputs and outputs:
 - .1 Ten Universal Inputs - shall be configured to monitor any of the following:
 - ◇ Analog Input, Voltage Mode
 - ◇ Analog Input, Current Mode
 - ◇ Analog Input, Resistive Mode

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- ◇ Binary Input, Dry Contact Maintained Mode
- ◇ Binary Input, Pulse Counter Mode
- .2 Eight Binary Inputs - shall be configured to monitor either of the following:
 - ◇ Dry Contact Maintained Mode
 - ◇ Pulse Counter Mode
- .3 Four Analog Outputs - shall be configured to output either of the following
 - ◇ Analog Output, Voltage Mode
 - ◇ Analog Output, Current Mode
- .4 Seven Binary Outputs - shall output the following:
 - ◇ 24 VAC Triac
- .5 Four Configurable Outputs - shall be configured to output either of the following:
 - ◇ Analog Output, Voltage Mode
 - ◇ Binary Output, 24 VAC Triac Mode
- 9. The NCE 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.
 - .3 The SA Bus shall operate at a maximum distance of 1,200 Ft. between the NCE and the furthest connected device.
- 10. The NCE 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 Field Trunk or the SA Bus.
- 11. The NCE shall support, but not be limited to, the following applications:
 - .1 Central Equipment including chillers and boilers
 - .2 Lighting and electrical distribution
 - .3 Built-up air handling units for special applications
 - .4 Power generation and energy monitoring equipment
 - .5 Interfaces to security and fire detection systems
- 12. The NCE shall support a Local Controller Display (DIS1710) either as an integral part of the NCE or as a remote device communicating over the SA Bus.
 - .1 The Display shall use a BACnet Standard SSPC-135, clause 9 Master-Slave/Token-Passing protocol.
 - .2 The Display shall allow the user to view monitored points without logging into the system.
 - .3 The Display shall allow the user to view and change setpoints, modes of operation, and parameters.
 - .4 The Display shall provide password protection with user adjustable password timeout.
 - .5 The Display shall be menu driven with separate paths for:
 - ◇ Input/Output
 - ◇ Parameter/Setpoint

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- ◇ Overrides
- .6 The Display shall use easy-to-read English text messages.
- .7 The Display shall allow the user to select the points to be shown and in what order.
- .8 The Display shall support a back lit Liquid Crystal Display (LCD) with adjustable contrast and brightens and automatic backlight brightening during user interaction.
- .9 The display shall be a minimum of 4 lines and a minimum of 20 characters per line
- .10 The Display shall have a keypad with no more than 6 keys.
- .11 The Display shall be panel mountable.
- 13. The NCE 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. NCE size and capability shall be sufficient to fully meet the requirements of this Specification.
- 14. The NCE shall employ an industrial single board computer.
- 15. Each NCE shall have sufficient memory to support its own operating system, databases, and control programs, and to provide supervisory control for all control level devices.
- 16. The NCE shall include an integrated, hardware-based, real-time clock.
- 17. The NCE shall employ nonvolatile Flash memory to store all programs and data. The NCE shall employ a data protection battery to save data and power the real time clock when primary power is interrupted.
- 18. The NCE shall provide removable, color coded, screw terminal blocks for 24 VAC power, communication bus and I/O point field wiring.
- 19. The NCE shall include troubleshooting LED indicators to identify the following conditions:
 - .1 Power
 - .2 Fault
 - .3 SA Bus
 - .4 FC Bus
 - .5 Modem TX
 - .6 Modem RX
 - .7 Battery Fault
 - .8 Ethernet
 - .9 10 LNK
 - .10 100 LNK
 - .11 Run
 - .12 Peer Com
- 20. Communications Ports – The NCE 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 USB port
 - .2 RS-232 serial data communication port

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- .3 RS-485 port
 - .4 RJ-45 Ethernet port
 - .5 RJ-12 jack
21. The NCE shall support an optional internal modem with RJ-12 6-pin telephone line connector.
22. Diagnostics – The NCE shall continuously perform self-diagnostics, communication diagnosis, and diagnosis of all panel components. The Network Control Engine shall provide both local and remote annunciation of any detected component failures, low battery conditions, or repeated failures to establish communication.
23. Power Failure – In the event of the loss of normal power, The NCE 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.
24. Certification – The NCE shall be listed by Underwriters Laboratories (UL). File E107041, CCN PAZX, UL 916, Energy Management Equipment. FCC Compliant to CFR47, Part 15, Subpart B, Class A
25. Field Controller Bus – The NCE shall support the following communication protocols on the Field Controller Bus:
- .1 The NCE shall support BACnet Standard MS/TP Bus Protocol ASHRAE SSPC-135, Clause 9 on the controller network.
 - ◇ The NCE shall be BACnet Testing Labs (BTL) certified and carry the BTL Label.
 - ◇ The NAE shall be tested and certified as a BACnet Building Controller (B-BC).
 - ◇ A BACnet Protocol Implementation Conformance Statement shall be provided for the NCE.
 - ◇ The Conformance Statements shall be submitted 10 days prior to bidding.
 - ◇ The NCE shall support a minimum of 32 control devices.
 - .2 The NCE shall support LonWorks enabled devices using the Free Topology Transceiver FTT10 on the Field Controller Bus (LonWorks Network).
 - ◇ All LonWorks controls devices shall be LonMark certified.
 - ◇ The NCE shall support a minimum of 32 LonWorks enabled control devices.
 - .3 The NCE shall support the N2 devices on the Field Controller Bus (Johnson Controls N2 Bus).
 - ◇ The NCE shall support a minimum of 32 N2 control devices.

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- ◇ The Bus shall conform to Electronic Industry Alliance (EIA) Standard RS-485.
- ◇ The Bus shall employ a master/slave protocol where the NCE is the master.
- ◇ The Bus shall employ a four (4) level priority system for polling frequency.
- ◇ The Bus shall be optically isolated from the NCE.
- ◇ The Bus shall support the Metasys Integrator System.

.5 BACnet 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:

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- .1 Universal Inputs - shall be configured to monitor any of the following:
 - ◇ Analog Input, Voltage Mode
 - ◇ Analog Input, Current Mode
 - ◇ Analog Input, Resistive Mode
 - ◇ Binary Input, Dry Contact Maintained Mode
 - ◇ Binary Input, Pulse Counter Mode
- .2 Binary Inputs - shall be configured to monitor either of the following:
 - ◇ Dry Contact Maintained Mode
 - ◇ Pulse Counter Mode
- .3 Analog Outputs - shall be configured to output either of the following:
 - ◇ Analog Output, Voltage Mode
 - ◇ Analog Output, current Mode
- .4 Binary Outputs - shall output the following:
 - ◇ 24 VAC Triac
- .5 Configurable Outputs - shall be capable of the following:
 - ◇ Analog Output, Voltage Mode
 - ◇ 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.
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
 - .3 Terminal units
 - .4 Special programs as required for systems control

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.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:
 - ◇ Analog Input, Voltage Mode
 - ◇ Analog Input, Current Mode
 - ◇ Analog Input, Resistive Mode
 - ◇ Binary Input, Dry Contact Maintained Mode
 - ◇ Binary Input, Pulse Counter Mode
 - .2 Binary Inputs - shall be configured to monitor either of the following:
 - ◇ Dry Contact Maintained Mode
 - ◇ Pulse Counter Mode
 - .3 Analog Outputs - shall be configured to output either of the following:
 - ◇ Analog Output, Voltage Mode
 - ◇ Analog Output, current Mode
 - .4 Binary Outputs - shall output the following:
 - ◇ 24 VAC Triac
 - .5 Configurable Outputs - shall be capable of the following:
 - ◇ Analog Output, Voltage Mode
 - ◇ 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.

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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
 - ◇ Mode
 - ◇ Fan
 - ◇ Override
 - ◇ Degrees C/F
 - ◇ Up/Down
 - .4 The display shall continuously scroll through the following parameters:
 - ◇ Room Temperature
 - ◇ System Mode
 - ◇ Schedule Status – Occupied/Unoccupied/Override
 - ◇ 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 2° F to 5° F
 - .3 Adjustable heating/cooling cycles per hour from 4 to 8

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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.

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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.
 - ◇ Absolute temperature loop error.
 - ◇ Signed temperature loop error.
 - ◇ Absolute airflow loop error.
 - ◇ Signed airflow loop error.
 - ◇ 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:
 - ◇ Unreliable space temperature sensor.
 - ◇ Unreliable differential pressure sensor.
 - ◇ Starved box.
 - ◇ Actuator stall
 - ◇ Insufficient cooling.
 - ◇ 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:
 - ◇ 0-10 VDC Sensors
 - ◇ 1000ohm RTDs

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- ◇ 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:
 - ◇ 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.

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- 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.

.7 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:
 - ◇ Setpoint reset slide switch providing a ±3 degree (adjustable) range.
 - ◇ Individual heating/cooling setpoint slide switches.
 - ◇ A momentary override request push button for activation of after-hours operation.
 - ◇ 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:
 - ◇ Display room and outside air temperatures.
 - ◇ Display and adjust room comfort setpoint.
 - ◇ Display and adjust fan operation status.

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- ◇ Timed override request push button with LED status for activation of after-hours operation.
 - ◇ Display controller mode.
 - ◇ 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" NPT 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 than 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.

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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 sealite 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 Operators 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:
 - ◇ .01-20" w.c. input differential pressure range.
 - ◇ 4-20 mA output.

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- ◇ Maintain accuracy up to 20 to 1 ratio turndown.
 - ◇ 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:
 - ◇ Differential pressure range 10" w.c. to 300 PSI.
 - ◇ 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:
 - ◇ -1.00 to +1.00 w.c. input differential pressure ranges. (Select range appropriate for system application)
 - ◇ 4-20 mA output.
 - ◇ Maintain accuracy up to 20 to 1 ratio turndown.
 - ◇ 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:
 - ◇ (0.00 - 1.00" to 5.00") w.c. input differential pressure ranges. (Select range appropriate for system application.)
 - ◇ 4-20 mA output.
 - ◇ Maintain accuracy up to 20 to 1 ratio turndown.
 - ◇ 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.)

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- .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:
 - ◇ Zero & span: (c/o F.S./Deg. F): .04% including linearity, hysteresis and repeatability.
 - ◇ Accuracy: 1% F.S. (best straight line) Static Pressure Effect: 0.5% F.S. (to 100 PSIG).
 - ◇ 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
 - ◇ 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.
 - ◇ 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 $\pm 20^\circ$ in the approaching air stream.
 - ◇ 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.
 - ◇ 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
 - ◇ 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

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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

- ◇ 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.
- ◇ 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.
- ◇ 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.
- ◇ 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.
- ◇ The main take-off point from both the total pressure and the static pressure manifolds must be symmetrical.
- ◇ 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.
- ◇ Installation Considerations
 - (i) *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.*
 - (ii) *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.*
 - (iii) *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.*

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- ◇ Manufactured to UL 1244.
- ◇ Accuracy: +.5%, Ripple +1%.
- ◇ Minimum load resistance 30kOhm.
- ◇ Input 0-20 Amps.
- ◇ Output 4-20 mA.
- ◇ Transducer shall be powered by a 24VDC regulated power supply (24 VDC +5%).
- ◇ Acceptable manufacturers: Veris Industries

.7 Refrigerant Leak Detectors.

1. The refrigerant leak detector shall be a standalone device and shall provide a SPDT output to directly energize the refrigeration room exhaust ventilation fans. The detector shall include a sensor or sensors connected to a control panel. Two relay contacts at the control panel shall provide trouble and alarm indication to the Facility Management System. The alarm relay contact shall also directly energize the exhaust fans.
2. The refrigerant leak detector shall sense the type of refrigerant used in the specified chillers. Multiple sensors shall be required to detect different refrigerants and/or provide proper sensing coverage for the area of the refrigeration room.
3. Acceptable manufacturers: Johnson Controls, Vulcain, MSA Instruments

.8 Smoke Detectors

1. Ionization type air duct detectors shall be furnished as specified elsewhere in Division 26 for installation under Division 23. All wiring for air duct detectors shall be provided under Division 26, 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.

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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 taps, 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.
- .8 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.

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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.

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- .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 Contractor shall furnish all automatic dampers. All automatic dampers shall be sized for the application by the BMS Contractor 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.

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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 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
- .4 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.
 - .4 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.
- .5 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,

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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.
- .6 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.
- .7 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.
- .8 Electronic/Pneumatic Transducers
1. Electronic to Pneumatic transducers shall provide:
 - .1 Output: 3-15 PSIG.

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- .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.

.9 Miscellaneous Devices

.1 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.

.2 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.

.3 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

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for all room-type instruments shall match and, unless otherwise indicated or specified, covers shall be manufacturer's standard finish.

Part 3 Performance / Execution

.1 BMS Specific Requirements

.1 Graphic Displays

1. Provide a 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 required for this project:

.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 handlers 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)

.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 Contractor unless specifically shown on the Electrical Drawings under Division 26 Electrical. All wiring shall comply with the requirements of applicable portions of Division 26 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 Contractor. If complications arise, however, due to the incorrect selection of cable, cable trays, raceways and/or conduit by the BMS Contractor, the Contractor shall be responsible for all costs incurred in replacing the selected components.

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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 26.
 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 Architect.
 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 contractor shall be responsible for coordinating panel locations with other trades and electrical and mechanical contractors.
- .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 contractor 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.

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- .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 contractor 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.

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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 Training

- .1 The BMS contractor 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.

.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 Contractor.
- .3 VAV box performance verification and documentation:
 1. The BMS Contractor 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 Contractor 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.

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.5 Sequences

.1 AHU 1&2 Sequence of operation.

1. New Air Handling Units (AHU-1 and AHU-2): Each air handling unit shall operate on it's own 7 day schedule capable of minimum 4 schedule changes per day.

.1 Occupied Winter Mode – (Below 15 deg. C)

- ◇ Blowers to operate continuously.
- ◇ Maintain discharge air temperature at set point. (DDC System shall control discharge air temperature on linear curve based on outdoor air temperature. Provide two operator adjustable min/max set points for discharge air and outdoor air for generating the curve.) Discharge temperature shall be overridden on call for space heating.
- ◇ Outside air damper and relief damper set to minimum position (operator adjustable). Outdoor damper minimum setting to be overridden by CO2 control on return air to bring in more outdoor air as required. CO2 control shall modulate the outdoor, relief and return dampers between the minimum set point and an operator adjustable maximum set point. The operator adjustable range shall be within 0% min to 30% max. (Initially set the min set point to 0% and max set point to 20%).
- ◇ Supply air low limit shall close fresh air damper based on low discharge air temperature and if discharge air temperature does not recover after time delay, shut down unit and alarm. Duration of time delay shall be operator adjustable. (Supply air low limit shall override CO2 control.)

.2 Occupied Summer Mode – (15 deg. C and above)

- ◇ Blowers to operate continuously.
- ◇ Maintain space temperature at set point. (Modulate outdoor air, relief air, and return air dampers to maintain space temperature at set point for free cooling where outdoor temperatures permit.)
- ◇ Outside air damper and relief damper set to minimum position (operator adjustable). Outdoor damper minimum setting to be overridden by CO2 control on return air to bring in more outdoor air as required. CO2 control shall modulate the outdoor, relief and return dampers between the minimum set point and an operator adjustable maximum set point.

.3 Unoccupied Mode (Heating and Cooling).

- ◇ Blowers to operate as required.
- ◇ Maintain space temperature at set-back point.
- ◇ Outdoor air dampers fully closed, return air dampers fully open.

.4 DDC system shall monitor the following:

- ◇ AHU fan status.
- ◇ Cooling Mode/Economizer Mode/Heating Mode.

CONTROL SYSTEM FOR HVAC

- ◇ Clogged filter
 - ◇ Return Air temperature
 - ◇ Outdoor air temperature
 - ◇ Mixed Air temperature
 - ◇ Supply Air temperature.
 - ◇ Supply Air Low Limit Status (Freeze Stat).
 - ◇ Damper positions.
 - ◇ Space temperature.
 - ◇ CO2 Levels.
2. Pumps PU-1 and PU-2
- .1 Enable ONE pump during winter mode. (Outdoor temperature below 15 deg. C) The other pump to remain on standby.
 - .2 In event of a pump failure, the standby pump shall start automatically. An alarm shall be generated to indicate pump failure.
 - .3 DDC system shall provide automatic duty cycling of the pumps based on equal run time (frequency to be operator adjustable).
 - .4 DDC System shall monitor pump status.
3. Glycol Fill Package:
- .1 DDC System shall monitor glycol fill package level and pressure.
4. Control Valves (all control valves supplied by 230933 and installed by mechanical).
- .1 The control valves shall be modulated to control glycol flow supplied to the air handler heating coils and to modulate steam flow to heat exchanger.
- .2 Alarms and Monitoring
- 1. DDC System shall monitor,
 - .1 Glycol supply temperature.
 - .2 Glycol return temperature.
 - 2. Alarms shall be generated on the DDC system for the following events:
 - .1 Clogged filters on air handling units (non critical)
 - .2 Freeze stat on air handling units (critical)
 - .3 Fan failure on air handling units (critical)
 - .4 Pump Failures (critical)
 - .5 Glycol fill package low level and low pressure (critical).
- .3 Thermostats and Temperature Sensors.
- 1. Provide duct mounted DDC temperature sensors suitable for specified operation.
 - 2. Provide space mounted DDC temperature sensors in the gym and the fitness room. The space temperature is to be set from the DDC system.

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.6 Existing N2 Controllers

.1 The BMS contractor shall provide the following:

1. Supply and install a new Network Control Engine (NCE) with integral N2 field bus capabilities.
2. Disconnect existing N2 controller bus from the existing leased line interface, and connect the bus to the new NCE. Turn over leased line equipment to Contract Administrator.
3. Interface these N2 points into the City of Winnipeg's existing ADX database server. Coordinate with City Winnipeg operations personnel.
4. Sequences, point description and graphics for these systems shall remain as-is.

END OF SECTION

HYDRONIC SYSTEMS: STEEL

Part 1 General

1.1 SUMMARY

- .1 Section Includes.
 - .1 Materials and installation for steel piping, valves and fittings for hydronic systems.
- .2 Related Sections.
 - .1 Section 01 33 00 - Submittal Procedures.
 - .2 Section 23 05 00 - Common Work Results - Mechanical.
 - .3 Section 23 05 93 - Testing, Adjusting and Balancing for HVAC.

1.2 REFERENCES

- .1 American Society of Mechanical Engineers (ASME).
 - .1 ASME B16.1-98, Cast Iron Pipe Flanges and Flanged Fittings.
 - .2 ASME B16.3-98, Malleable Iron Threaded Fittings.
 - .3 ASME B16.5-03, Pipe Flanges and Flanged Fittings.
 - .4 ASME B16.9-01, Factory-Made Wrought Buttwelding Fittings.
 - .5 ASME B18.2.1-03, Square and Hex Bolts and Screws (Inch Series).
 - .6 ASME B18.2.2-87(R1999), Square and Hex Nuts (Inch Series).
- .2 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM A47/A47M-99, Standard Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A53/A53M-02, Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated Welded and Seamless.
 - .3 ASTM A536-84(1999)e1, Standard Specification for Ductile Iron Castings.
 - .4 ASTM B61-02, Standard Specification for Steam or Valve Bronze Castings.
 - .5 ASTM B62-02, Standard Specification for Composition Bronze or Ounce Metal Castings.
 - .6 ASTM E202-00, Standard Test Method for Analysis of Ethylene Glycols and Propylene Glycols.
- .3 American Water Works Association (AWWA).
 - .1 AWWA C111-00, Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- .4 Canadian Standards Association (CSA International).
 - .1 CSA B242-M1980(R1998), Groove and Shoulder Type Mechanical Pipe Couplings.
 - .2 CAN/CSA W48-01, Filler Metals and Allied Materials for Metal Arc Welding (Developed in cooperation with the Canadian Welding Bureau).
- .5 Manufacturer's Standardization of the Valve and Fittings Industry (MSS).
 - .1 MSS-SP-67-025, Butterfly Valves.

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- .2 MSS-SP-70-98, Cast Iron Gate Valves, Flanged and Threaded Ends.
- .3 MSS-SP-71-97, Cast Iron Swing Check Valves Flanged and Threaded Ends.
- .4 MSS-SP-80-03, Bronze Gate, Globe, Angle and Check Valves.
- .5 MSS-SP-85-02, Cast Iron Globe and Angle Valves, Flanged and Threaded Ends.

1.3 SUBMITTALS

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

1.4 MAINTENANCE

- .1 Extra Materials.
 - .1 Provide following spare parts:
 - .1 Valve seats: one for every ten valves, each size. Minimum one.
 - .2 Discs: one for every ten valves, each size. Minimum one.
 - .3 Stem packing: one for every ten valves, each size. Minimum one.
 - .4 Valve handles: two of each size.
 - .5 Gaskets for flanges: one for every ten flanges.

Part 2 Products

2.1 PIPE

- .1 Steel pipe: to ASTM A53/A53M, Grade B, as follows:
 - .1 To NPS6: Schedule 40.

2.2 PIPE JOINTS

- .1 NPS2 and under: screwed fittings with PTFE tape or lead-free pipe dope.
- .2 NPS2-1/2 and over: welding fittings and flanges to CAN/CSA W48.
- .3 Flanges: plain, to AWWA C111.
- .4 Orifice flanges: slip-on raised face, 2100 kPa.
- .5 Flange gaskets: to AWWA C111.
- .6 Pipe thread: taper.
- .7 Bolts and nuts: to ASME B18.2.1 and ASME B18.2.2.

2.3 FITTINGS

- .1 Screwed fittings: malleable iron, to ASME B16.3, Class 150.

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- .2 Pipe flanges and flanged fittings:
 - .1 Cast iron: to ASME B16.1, Class 125.
 - .2 Steel: to ASME B16.5.
- .3 Butt-welding fittings: steel, to ASME B16.9.
- .4 Unions: malleable iron, to ASTM A47/A47M and ASME B16.3.

2.4 VALVES

- .1 Connections:
 - .1 NPS2 and smaller: screwed ends.
 - .2 NPS2.1/2 and larger: Flanged ends.
- .2 Ball Valves
 - .1 NPS2 and under:
 - .1 To ASTM B62, 4 MPa WOG, bronze body, screwed ends, TFE seal, hard chrome solid ball, Teflon seats and lever handle.
 - .2 Acceptable product: Toyo Figure 5044A, Crane, Grinnell or approved equal.
 - .3 Gate valves:
 - .1 NPS2 and under:
 - .1 Rising stem: to MSS SP-80, Class 125, 860 kPa, bronze body, solid wedge disc.
 - .2 Acceptable material: Toyo Fig 206A, Crane, Grinnell.
 - .2 NPS2 1/2 and over:
 - .1 Rising stem, OS & Y, bolted bonnet, solid wedge, disc flanged end, to MSS SP-70, cast iron body bronze trim.
 - .2 Acceptable material: Toyo Fig No. 421A, Crane, Grinnell.
- .4 Butterfly valves: to MSS-SP-67:
 - .1 NPS2 1/2 and over: Lug type:
- .5 Balancing, for TAB:
 - .1 Sizes: Calibrated balancing valves, as specified this section.
 - .2 NPS2 and under:
 - .1 Threaded bronze body construction, brass ball, TFE seat rings c/w memory stop, and differential pressure readout ports.
 - .2 Acceptable product: Bell & Gossett Circuit Setter plus Model CB.
 - .3 NPS 2 1/2 and over:
 - .1 flanged cast iron body construction, c/w memory stop, and differential pressure readout ports.
 - .2 Acceptable Product: Bell & Gossett Circuit Setter Model CB.

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- .6 Air Vents:
 - .1 Automatic air vent suitable for hot water heating system with semi steel body and stainless steel float. Size = 12 mm.
 - .2 Acceptable Product: Hamlet and Garneau Model MV-15.
- .7 Strainers:
 - .1 To ASTM B62, bronze body, cover, plug, screwed ends, 20 mesh screen.
 - .2 Acceptable Product: SF TB300 or approved equal.
- .8 Air Purger:
 - .1 75 mm air purger suitable for water heating systems with automatic air vent and ball valve on fill connection.
 - .2 Acceptable Product: Hamlet and Garneau Model P-300 air purger with MV-15 air vent.
- .9 Expansion Tank EXP-1:
 - .1 ASME rated full replaceable bladder expansion tank with pre-charge air connection and 19 mm (3/4") system connection as stated below:

.1	Volume (L)	300
.2	Fluid	50%Prop.Glycol / 50%Water
.3	Height (mm)	1400
.4	Diameter (mm)	610
 - .2 Acceptable Product: "Hamlet and Garneau" Model: AL-300V.
- .10 Heat Transfer Fluid:
 - .1 Fluid shall be 50% propylene glycol and 50% water.
 - .2 Provide a high-grade inhibited propylene glycol to ASTM -D1384 standards.
 - .3 Provide either distilled or deionized water with less than 25 ppm each of chloride and sulphate, and less than 50 ppm each of hard water ions (calcium and magnesium as calcium carbonate) with total hardness not to exceed 100 ppm.
- .11 Glycol Fill Package GP-1
 - .1 Glycol fill package (Hydronic system feeder) c/w 65 L storage/mixing tank with molded-in level gauge, 125mm fill/access opening and cover, pump suction hose with inlet strainer and check valve, pressure pump with fuse protection, low fluid level pump cut-out float switch, manual diverter valve for purging air and agitating contents of storage tank, pressure switch with snubber and two sets of SPST contacts, each individually adjustable from 55 kPa to 125 kPa cut out pressure, and liquid filled pressure gauge. The unit shall be c/w power supply adapter, 115/1/60 to 24 VDC 50 W AC, supplied loose for field installation.
 - .2 The unit shall be compatible with 50% Propylene Glycol solution. Pump shall be capable of running dry without damage. The second set of contacts in the pressure switch shall be wired to a terminal strip for use as low pressure

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alarm contacts for remote alarm. Unit shall come c/w optional low level alarm panel c/w remote monitoring dry contacts.

- .3 Acceptable Product: "AXIOM" Model MF300 c/w RIA10-1-SAA.

.12 Chemical Pot Feeder:

- .1 7.6 L by-pass feeder, 1380 kPa (200 psig) working pressure, construction: 11 gauge steel tank shell and heads, cast iron with Buna N seal tank cap.
- .2 Acceptable Product: "BetzDearborn – Neptune Bypass Feeder" Model: BDF-2.
- .3 Accessories: Provide initial chemical treatment, test kit, and Site inspections as supplied by BetzDearborn.

.13 Filter:

- .1 Filter housing and cartridge, cast iron head, carbon steel shell, 19 mm ($\frac{3}{4}$ " inlet and outlet, carbon steel capscrew drain.
- .2 Acceptable Product: "BetzDearborn – Filterite" Model: LMO10 and 30 micron filter cartridge.

.14 Flow Indicator:

- .1 20 mm flow indicator, 304 stainless steel body and internals, fused glass window, metric and U.S. scales (15-30 lpm and 4-8 gpm), stainless steel return spring, 1082 kPa maximum pressure.
- .2 Acceptable Product: "BetzDearborn" Model: Filter-Mate $\frac{3}{4}$

Part 3 Execution

3.1 PIPING INSTALLATION

- .1 Connect to equipment in accordance with manufacturer's instruction unless otherwise indicated.
- .2 Install pipe to conserve headroom and space. Run exposed piping parallel to walls. Group piping wherever practical.
- .3 Slope piping in direction of drainage and for positive venting.
- .4 Use eccentric reducers at pipe size change installed to provide positive drainage or positive venting.
- .5 Provide clearance for installation of insulation and access for maintenance of equipment, valves and fittings.
- .6 Ream pipes, clean scale and dirt, inside and outside, before and after assembly.
- .7 Assemble piping using fittings manufactured to ANSI standards.

HYDRONIC SYSTEMS: STEEL

3.2 CIRCUIT BALANCING VALVES

- .1 Install flow measuring stations and flow balancing valves as indicated.
- .2 Remove handwheel after installation and when TAB is complete.
- .3 Tape joints in prefabricated insulation on valves installed in chilled water mains.

3.3 CLEANING, FLUSHING AND START-UP

- .1 Flush entire water system after pressure test for a minimum of 4 h.
- .2 Fill with solution of water and non-foaming, phosphate-free detergent 3% solution by weight. Circulate for minimum of 8 h.
- .3 Drain and flush for 4 h. Remove strainer screen/basket and clean.
- .4 Refill system with clean water and circulate minimum 2 h.
- .5 Drain and flush for 2 h. Remove strainer screen/basket and clean. Re-install after obtaining approval.

3.4 TESTING

- .1 Test system in accordance with Section 23 05 00 - Common Work Results - Mechanical.
- .2 For glycol systems, retest with propylene glycol to ASTM E202, inhibited, for use in building system after cleaning. Repair leaking joints, fittings or valves.

3.5 BALANCING

- .1 Balance water systems to within plus or minus 5% of design output.
- .2 Refer to Section 23 05 93 - Testing, Adjusting and Balancing for HVAC for applicable procedures.

3.6 GLYCOL CHARGING

- .1 Provide mixing tank and positive displacement pump for glycol charging.
- .2 Retest for concentration to ASTM E202 after cleaning.

3.7 AIR VENTS

- .1 Install at system high points. Install air vents with isolation ball valve.

END OF SECTION

HYDRONIC PUMPS

Part 1 General

1.1 SECTION INCLUDES

- .1 Materials, equipment selection, installation and start up for hydronic system pumps.

1.2 REFERENCES

- .1 American Society of Heating Refrigeration and Air-Conditioning Engineers (ASHRAE).
 - .1 Standard 90.1-2001 Energy Standard for Buildings Except Low-Rise Residential Buildings.
- .2 Electrical Equipment Manufacturers Advisory Council (EEMAC).
- .3 Canadian Standards Association (CSA International).
 - .1 CAN/CSA-B214-01, Installation Code for Hydronic Heating Systems.
- .4 National Electrical Manufacturers Association (NEMA).
 - .1 NEMA MG 1-2003, Motors and Generators.

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Submit shop drawings and product data in accordance with Section 01 33 00 - Submittal Procedures.
- .3 Submit manufacturer's detailed composite wiring diagrams for control systems showing factory installed wiring and equipment on packaged equipment or required for controlling devices or ancillaries, accessories and controllers.
- .4 Submit product data of pump curves for review showing point of operation.
- .5 Indicate piping, valves and fittings shipped loose by packaged equipment supplier, showing their final location in field assembly.
- .6 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

Part 2 Products

2.1 INLINE CENTRIFUGAL PUMPS PU-1 AND PU-2

- .1 Volute: cast iron radially split, flanged design suction and discharge connections.
- .2 Impeller: cast bronze
- .3 Shaft: alloy steel with aluminium bronze sleeve bearing, integral thrust collar.
- .4 Seal assembly: mechanical for service to 135°C.

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- .5 Coupling: rigid self-aligning.
- .6 Motor: ODP, high efficiency sleeve bearing, 1750 RPM, 1.1 kW (1.5 HP), 575 V/3 ph.
- .7 Capacity: 4.16 l/s at 74.7 kPa (66 usgpm @ 25 ft.)
- .8 Design pressure: 1200 kPa (175 psi)
- .9 Pump motor shall not be overloading anywhere on its curve.
- .10 Acceptable Product: "ITT Bell & Gossett" Series 60 2 x 2 x 5 ¼.

Part 3 Execution

3.1 INSTALLATION

- .1 Do Work in accordance with CAN/CSA-B214.
- .2 In line circulators: install as indicated by flow arrows. Support at inlet and outlet flanges or unions. Install with bearing lubrication points accessible.
- .3 Base mounted type: supply templates for anchor bolt placement. Furnish anchor bolts with sleeves. Place level, shim unit and grout. Align coupling in accordance with manufacturer's recommended tolerance.
- .4 Ensure that pump body does not support piping or equipment. Provide stanchions or hangers for this purpose. Refer to manufacturer's installation instructions for details.
- .5 Install volute venting pet cock in accessible location.
- .6 Check rotation prior to start-up.
- .7 Install pressure gauge test cocks.

3.2 START-UP

- .1 General
 - .1 In accordance with Section 01 91 13 - Commissioning: General Requirements; supplemented as specified herein.
 - .2 In accordance with manufacturer's recommendations.
- .2 Procedures:
 - .1 Before starting pump, check that cooling water system over-temperature and other protective devices are installed and operative.
 - .2 After starting pump, check for proper, safe operation.
 - .3 Check installation, operation of mechanical seals, packing gland type seals. Adjust as necessary.
 - .4 Check base for free-floating, no obstructions under base.

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- .5 Run-in pumps for 12 continuous hours.
- .6 Verify operation of over-temperature and other protective devices under low- and no-flow condition.
- .7 Eliminate air from scroll casing.
- .8 Adjust water flow rate through water-cooled bearings.
- .9 Adjust flow rate from pump shaft stuffing boxes to manufacturer's recommendation.
- .10 Adjust alignment of piping and conduit to ensure true flexibility at all times.
- .11 Eliminate cavitation, flashing and air entrainment.
- .12 Adjust pump shaft seals, stuffing boxes, glands.
- .13 Measure pressure drop across strainer when clean and with flow rates as finally set.
- .14 Replace seals if pump used to degrease system or if pump used for temporary heat.
- .15 Verify lubricating oil levels.

3.3 PERFORMANCE VERIFICATION (PV)

- .1 General
 - .1 In accordance with Section 01 91 13 - Commissioning: General Requirements, supplemented as specified herein.
 - .2 In accordance with manufacturer's recommendations.
- .2 Exclusions:
 - .1 This paragraph does not apply to small in-line circulators.
- .3 Assumptions: these PV procedures assume that:
 - .1 Manufacturer's performance curves are accurate.
 - .2 Valves on pump suction and discharge provide tight shut-off.
- .4 Net Positive Suction Head (NPSH):
 - .1 Application: measure NPSH for pumps which operate on open systems and with water at elevated temperatures.
 - .2 Measure using procedures prescribed in the Standard.
 - .3 Where procedures do not exist, discontinue PV, report to Contract Administrator and await instructions.
- .5 Multiple Pump Installations - Series and Parallel:
 - .1 Repeat PV procedures specified above for pump performance and pump BHP for combinations of pump operations.
- .6 Mark points of design and actual performance at design conditions as finally set upon completion of TAB.

END OF SECTION

STEAM AND CONDENSATE HEATING PIPING

Part 1 General

1.1 SECTION INCLUDES

- .1 Materials and installation of steel piping valves, fittings for steam and condensate building services piping.

1.2 RELATED SECTIONS

- .1 Section 01 33 00 - Submittal Procedures.
- .2 Section 01 78 00 - Closeout Submittals.
- .3 Section 01 91 13 - Commissioning.
- .4 Section 23 05 00 - Common Work Results - Mechanical.

1.3 REFERENCES

- .1 American National Standards Institute (ANSI).
 - .1 ANSI/ASME B16.1-[98], Cast Iron Pipe Flanges and Flanged Fittings.
 - .2 ANSI/ASME B16.25-[97], Buttwelding Ends.
 - .3 ANSI/ASME B16.3-[98], Malleable Iron Threaded Fittings.
 - .4 ANSI/ASME B16.5-[03], Pipe Flanges and Flanged Fittings.
 - .5 ANSI/ASME B16.9-[01], Factory-Made Wrought Steel Buttwelding Fittings.
 - .6 ANSI B18.2.1-[03], Square and Hex Bolts and Screws (Inch Series).
 - .7 ANSI/ASME B18.2.2-[87(R1999)], Square and Hex Nuts (Inch Series).
- .2 American Water Works Association (AWWA).
 - .1 AWWA C111-[2000], Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- .3 American Society for Testing and Materials International, (ASTM).
 - .1 ASTM A47/A47M-[99], Standard Specification for Ferritic Malleable Iron Castings.
 - .2 ASTM A53/A53M-[02], Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc Coated, Welded and Seamless.
 - .3 ASTM A126-[95(2001)], Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
- .4 Canadian Standards Association (CSA International).
 - .1 CSA W48-[01], Filler Metals and Allied Materials for Metal Arc Welding (Developed in cooperation with the Canadian Welding Bureau).
- .5 Manufacturers Standardization Society of the Valve and Fittings Industry, Inc.
 - .1 MSS-SP-70-[98], Cast Iron Gate Valves, Flanged and Threaded Ends.

STEAM AND CONDENSATE HEATING PIPING

- .2 MSS-SP-71-[97], Gray Iron Swing Check Valves, Flanged and Threaded Ends.
- .3 MSS-SP-80-[97], Bronze Gate, Globe, Angle and Check Valves.
- .4 MSS-SP-85-[94], Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.

1.4 SUBMITTALS

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

Part 2 Products

2.1 PIPE

- .1 Steel pipe: to ASTM A53/A53M, Grade B, as follows:
 - .1 Steam: SCH. 80.
 - .2 Condensate: SCH. 40.

2.2 PIPE JOINTS

- .1 NPS 2 and under: screwed fittings with PTFE tape or lead-free dope.
- .2 NPS 2-1/2 and over: welding fittings and flanges to CSA W48.
- .3 Flanges: plain or raised face. Flange gaskets to AWWA C111.
- .4 Pipe thread: taper.
- .5 Bolts and nuts: carbon steel, to ANSI/ASME B18.2.1 and ANSI/ASME B18.2.2.
- .6 Buttwelding ends: to ANSI/ASME B16.25.

2.3 FITTINGS

- .1 Pipe flanges: cast-iron to ANSI/ASME B16.1, Class 125.
- .2 Screwed fittings: malleable iron to ANSI/ASME B16.3, Class 150.
- .3 Steel pipe gaskets, flanges and flanged fittings: to ANSI/ASME B16.5.
- .4 Buttwelding fittings: steel to ANSI/ASME B16.9.
- .5 Unions: malleable iron, to ASTM A47/A47M and ANSI/ASME B16.3.

STEAM AND CONDENSATE HEATING PIPING

2.4 STEAM TRAP

- .1 Inline ball float steam trap, rated for 300 kgh @ 6.9 kPa (665 PPH @ 1 PSI), 25mm (1”) NTP connections, SG iron body, stainless steel internals, 2500 kPa maximum pressure @ 100 °C,
- .2 Acceptable Product: “Spirax Sarco” Model: FT14 HC -4.5

2.5 VALVES

- .1 Connections:
 - .1 NPS 2 and smaller: screwed ends.
 - .2 NPS 2 1/2 and larger:
 - .1 Equipment: Flanged ends.
 - .2 Elsewhere: Flanged ends.
- .2 Gate valves: Application: Steam service, for isolating equipment, control valves, pipelines.
 - .1 NPS 2 and under:
 - .1 Class 125, rising stem, wedge disc.
 - .2 NPS 2 1/2 -8:
 - .1 Class 150, rising stem, wedge disc, cast iron, bronze trim.
- .3 Gate valves: Application: condensate return service.
 - .1 NPS 2 and under:
 - .1 Class 125, rising stem, wedge disc.
 - .2 NPS 2 1/2 and over:
 - .1 Class 125, rising stem, split wedge disc, cast iron, bronze trim.

2.6 VALVE OPERATORS

- .1 Handwheel: on valves except as specified.

Part 3 Execution

3.1 PIPING

- .1 Connect branch lines into top of mains.
- .2 Install piping in direction of flow with slopes as follows, unless otherwise indicated:
 - .1 Steam: 1:240.

STEAM AND CONDENSATE HEATING PIPING

- .2 Condensate return: 1:70.
- .3 Make provision for thermal expansion as indicated.
- .4 Drip pocket: line size.

3.2 TESTING

- .1 Test system in accordance with Section 23 05 00 - Common Work Results - Mechanical.
- .2 Test pressure: 1-1/2 times maximum system operating pressure or 860 kPa whichever is greater.

END OF SECTION

METAL DUCTS - LOW PRESSURE TO 500 PA

Part 1 General

1.1 SUMMARY

.1 Section Includes:

.1 Materials and installation of low-pressure metallic ductwork, joints and accessories.

1.2 REFERENCES

.1 American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE).

.2 American Society for Testing and Materials International, (ASTM).

.1 ASTM A480/A480M-03c, Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet and Strip.

.2 ASTM A635/A635M-02, Standard Specification for Steel, Sheet and Strip, Heavy-Thickness Coils, Carbon, Hot Rolled.

.3 ASTM A653/A653M-03, Standard Specification for Steel Sheet, Zinc Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

.3 Department of Justice Canada (Jus).

.1 Canadian Environmental Protection Act (CEPA), 1999, c. 33 .

.4 Health Canada/Workplace Hazardous Materials Information System (WHMIS).

.1 Material Safety Data Sheets (MSDS).

.5 National Fire Protection Association (NFPA).

.1 NFPA 90A-02, Standard for the Installation of Air-Conditioning and Ventilating Systems.

.2 NFPA 90B-02, Standard for the Installation of Warm Air Heating and Air-Conditioning Systems.

.3 NFPA 96-01, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.6 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).

.1 SMACNA HVAC Duct Construction Standards - Metal and Flexible, 2nd Edition 1995 and Addendum No. 1, 1997.

.2 SMACNA HVAC Air Duct Leakage Test Manual, 1985, 1st Edition.

.3 IAQ Guideline for Occupied Buildings Under Construction 1995, 1st Edition.

.7 Transport Canada (TC).

.1 Transportation of Dangerous Goods Act (TDGA), 1992, c. 34.

METAL DUCTS - LOW PRESSURE TO 500 PA

1.3 QUALITY ASSURANCE

- .1 Certification of Ratings:
 - .1 Catalogue or published ratings shall be those obtained from tests carried out by manufacturer or independent testing agency signifying adherence to codes and standards.

Part 2 Products

2.1 SEAL CLASSIFICATION

- .1 Classification as follows:

<u>Maximum Pressure Pa</u>	<u>SMACNA Seal Class</u>
500	C
250	C
125	C

- .2 Seal classification:
 - .1 Class A: longitudinal seams, transverse joints, duct wall penetrations and connections made airtight with sealant and tape.
 - .2 Class B: longitudinal seams, transverse joints and connections made airtight with sealant.
 - .3 Class C: transverse joints and connections made air tight with gaskets, sealant or combination thereof. Longitudinal seams unsealed.

2.2 SEALANT

- .1 Sealant: oil resistant, polymer type flame resistant duct sealant. Temperature range of minus 30 degrees C to plus 93 degrees C.

2.3 DUCT LEAKAGE

- .1 In accordance with SMACNA HVAC Air Duct Leakage Test Manual.

2.4 FITTINGS

- .1 Fabrication: to SMACNA.
- .2 Radiused elbows.
 - .1 Rectangular: standard radius or short radius with single thickness turning vanes. Centreline radius: 1.5 times width of duct.
 - .2 Round: smooth radius. Centreline radius: 1.5 times diameter.
- .3 Mitred elbows, rectangular:
 - .1 To 400 mm: with single thickness turning vanes.
 - .2 Over 400 mm: with double thickness turning vanes.

METAL DUCTS - LOW PRESSURE TO 500 PA

- .4 Branches:
 - .1 Rectangular main and branch: with radius on branch 1.5 times width of duct or 45 degrees entry on branch.
 - .2 Round main and branch: enter main duct at 45 degrees with conical connection.
 - .3 Provide volume control damper in branch duct near connection to main duct.
 - .4 Main duct branches: with splitter damper.
- .5 Transitions:
 - .1 Diverging: 20 degrees maximum included angle.
 - .2 Converging: 30 degrees maximum included angle.
- .6 Offsets:
 - .1 as indicated.
- .7 Obstruction deflectors: maintain full cross-sectional area.
 - .1 Maximum included angles: as for transitions.

2.5 GALVANIZED STEEL

- .1 Lock forming quality: to ASTM A653/A653M, Z90 zinc coating.
- .2 Thickness, fabrication and reinforcement: to SMACNA.
- .3 Joints: to SMACNA.

2.6 HANGERS AND SUPPORTS

- .1 Hangers and Supports:
 - .1 Strap hangers: of same material as duct but next sheet metal thickness heavier than duct.
 - .1 Maximum size duct supported by strap hanger: 500.
 - .2 Hanger configuration: to ASHRAE and SMACNA.
 - .3 Hangers: galvanized steel angle with galvanized steel rods to following table:

Duct Size (mm)	Angle Size (mm)	Rod Size (mm)
up to 750	25 x 25 x 3	6
751 to 1050	40 x 40 x 3	6
1051 to 1500	40 x 40 x 3	10
1501 to 2100	50 x 50 x 3	10
2101 to 2400	50 x 50 x 5	10
2401 and over	50 x 50 x 6	10

METAL DUCTS - LOW PRESSURE TO 500 PA

- .4 Upper hanger attachments:
 - .1 For concrete: manufactured concrete inserts.
 - .2 For steel joist: manufactured joist clamp.
 - .3 For steel beams: manufactured beam clamps.

Part 3 Execution

3.1 GENERAL

- .1 Do work in accordance with SMACNA as indicated.
- .2 Do not break continuity of insulation vapour barrier with hangers or rods.
 - .1 Ensure diffuser is fully seated.
- .3 Support risers in accordance with SMACNA.
- .4 Install breakaway joints in ductwork on sides of fire separation.
- .5 Install proprietary manufactured flanged duct joints in accordance with manufacturer's instructions.

3.2 HANGERS

- .1 Strap hangers: install in accordance with SMACNA.
- .2 Angle hangers: complete with locking nuts and washers.
- .3 Hanger spacing: in accordance with SMACNA:

3.3 WATERTIGHT DUCT

- .1 Fit base of riser with 150 mm deep drain sump and 32 mm drain connected, with deep seal trap and discharging to open funnel drain or as indicated.

3.4 SEALING AND TAPING

- .1 Apply sealant to outside of joint to manufacturer's recommendations.

3.5 LEAKAGE TESTS

- .1 In accordance with SMACNA HVAC Duct Leakage Test Manual.
- .2 Do leakage tests in sections.
- .3 Make trial leakage tests as instructed to demonstrate workmanship.
- .4 Do not install additional ductwork until trial test has been passed.
- .5 Complete test before performance insulation or concealment Work.

END OF SECTION

AIR DUCT ACCESSORIES

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Materials and installation for duct accessories including flexible connections, access doors, vanes and collars.

1.2 REFERENCES

- .1 Health Canada/Workplace Hazardous Materials Information System (WHMIS).
 - .1 Material Safety Data Sheets (MSDS).
- .2 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA).
 - .1 SMACNA - HVAC Duct Construction Standards - Metal and Flexible, [95].

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and data sheet. Indicate the following:
 - .1 Flexible connections.
 - .2 Duct access doors.
 - .3 Turning vanes.
 - .4 Instrument test ports.

Part 2 Products

2.1 GENERAL

- .1 Manufacture in accordance with SMACNA - HVAC Duct Construction Standards.

2.2 FLEXIBLE CONNECTIONS

- .1 Frame: galvanized sheet metal frame with fabric clenched by means of double locked seams.
- .2 Material:
 - .1 Fire resistant, self extinguishing, neoprene coated glass fabric, temperature rated at minus 40 degrees C to plus 90 degrees C, density of 1.3 kg/m².

2.3 ACCESS DOORS IN DUCTS

- .1 Non-Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame.

AIR DUCT ACCESSORIES

- .2 Insulated Ducts: sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm thick complete with sheet metal angle frame and 25 mm thick rigid glass fibre insulation.
- .3 Gaskets: neoprene.
- .4 Hardware:
 - .1 Up to 300 x 300 mm: two sash locks.
 - .2 301 to 450 mm: four sash locks.
 - .3 451 to 1000 mm: piano hinge and minimum two sash locks.
 - .4 Doors over 1000 mm: piano hinge and two handles operable from both sides.

2.4 TURNING VANES

- .1 Factory or shop fabricated single thickness with trailing edge, to recommendations of SMACNA.

2.5 SPIN-IN COLLARS

- .1 Conical galvanized sheet metal spin-in collars with lockable butterfly damper.
- .2 Sheet metal thickness to co-responding round duct standards.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and data sheet.

3.2 INSTALLATION

- .1 Flexible Connections:
 - .1 Install in following locations:
 - .1 Inlets and outlets of exhaust air fans.
 - .2 As indicated.
 - .2 Length of connection: 100 mm.
 - .3 Minimum distance between metal parts when system in operation: 75 mm.
 - .4 Install in accordance with recommendations of SMACNA.
 - .5 When fan is running:
 - .1 Ducting on sides of flexible connection to be in alignment.
 - .2 Ensure slack material in flexible connection.

AIR DUCT ACCESSORIES

- .2 Access Doors and Viewing Panels:
 - .1 Locations:
 - .1 Fire and smoke dampers.
 - .2 Control dampers.
 - .3 Devices requiring maintenance.
 - .4 Required by code.
 - .5 Reheat coils.
 - .6 Elsewhere as indicated.
 - .3 Instrument Test Ports:
 - .1 General:
 - .1 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
 - .2 Locate to permit easy manipulation of instruments.
 - .3 Install insulation port extensions as required.
 - .4 Locations:
 - .1 For traverse readings:
 - .1 Ducted inlets to roof and wall exhausters.
 - .2 Inlets and outlets of other fan systems.
 - .3 Main and sub-main ducts.
 - .4 And as indicated.
 - .2 For temperature readings:
 - .1 At outside air intakes.
 - .2 At inlet and outlet of coils.
 - .3 Downstream of junctions of two converging air streams of different temperatures.
 - .4 And as indicated.
- .4 Turning vanes:
 - .1 Install in accordance with recommendations of SMACNA and as indicated.

END OF SECTION

DAMPERS - BALANCING

Part 1 General

1.1 SUMMARY

.1 Section Includes:

- .1 Balancing dampers for mechanical forced air ventilation and air conditioning systems.

1.2 REFERENCES

.1 Sheet Metal and Air Conditioning National Association (SMACNA)

- .1 SMACNA HVAC Duct Construction Standards, Metal and Flexible-1985.

.2 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

- .1 Material Safety Data Sheets (MSDS).

1.3 SUBMITTALS

.1 Product Data:

- .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

Part 2 Products

2.1 GENERAL

.1 Manufacture to SMACNA standards.

2.2 SINGLE BLADE DAMPERS

.1 Fabricate from same material as duct, but one sheet metal thickness heavier. V-groove stiffened.

.2 Size and configuration to recommendations of SMACNA.

.3 Locking quadrant.

.4 Inside and outside nylon end bearings.

.5 Channel frame of same material as adjacent duct, complete with angle stop.

2.3 MULTI-BLADED DAMPERS

.1 Factory manufactured of material compatible with duct.

.2 Opposed blade: configuration, metal thickness and construction to recommendations of SMACNA.

DAMPERS - BALANCING

- .3 Bearings: self-lubricating nylon.
- .4 Linkage: shaft extension with locking quadrant.
- .5 Channel frame of same material as adjacent duct, complete with angle stop.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 Install where indicated.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.
- .3 Locate balancing dampers in each branch duct, for supply, return and exhaust systems.
- .4 Runouts to registers and diffusers: install single blade damper located as close as possible to main ducts.
- .5 Dampers: vibration free.
- .6 Ensure damper operators are observable and accessible.

END OF SECTION

HVAC FANS

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Fans, motors, accessories and hardware.

1.2 REFERENCES

- .1 Air Conditioning and Mechanical Contractors (AMCA)
 - .1 AMCA Publication 99-2003, Standards Handbook.
 - .2 AMCA 300-1996, Reverberant Room Method for Sound Testing of Fans.
 - .3 AMCA 301-1990, Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- .2 American National Standards Institute (ANSI)/American Society of Mechanical Engineers (ASME)
 - .1 ANSI/AMCA 210-1999, Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.
- .3 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 1.181-99, Ready-Mixed Organic Zinc-Rich Coating.
- .4 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 SYSTEM DESCRIPTION

- .1 Performance Requirements:
 - .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards in force.
 - .2 Capacity: flow rate, static pressure, bhp, efficiency, revolutions per minute, power, model, size, sound power data and as indicated on schedule.
 - .3 Fans: statically and dynamically balanced, constructed in conformity with AMCA 99.
 - .4 Sound ratings: comply with AMCA 301, tested to AMCA 300. Supply unit with AMCA certified sound rating seal.
 - .5 Performance ratings: based on tests performed in accordance with ANSI/AMCA 210. Supply unit with AMCA certified rating seal.

1.4 SUBMITTALS

- .1 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with section 01 33 00. Include product characteristics, performance criteria, and limitations.

HVAC FANS

- .2 Shop Drawings:
 - .1 Submit shop drawings and product data in accordance with section 01 33 00.
- .3 Provide:
 - .1 Fan performance curves showing point of operation, BHP and efficiency.
 - .2 Sound rating data at point of operation.
- .4 Indicate:
 - .1 Motors, sheaves, bearings, shaft details.

1.5 MAINTENANCE

- .1 Extra Materials:
 - .1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
 - .1 Spare parts to include:
 - .1 Matched sets of belts.
 - .2 Furnish list of individual manufacturer's recommended spare parts for equipment, include:
 - .1 Bearings and seals.
 - .2 Addresses of suppliers.
 - .3 List of specialized tools necessary for adjusting, repairing or replacing.

1.6 DELIVERY, STORAGE, AND HANDLING

- .1 Packing, shipping, handling and unloading:
 - .1 Deliver, store and handle materials in accordance with manufacturer's written instructions.

Part 2 Products

2.1 EXHAUST FANS (EF-2)

- .1 Centrifugal belt drive utility fan to match the existing exhaust fan, rated for 378 L/s @ 62Pa (800 CFM @ .25" ESP), ¼ HP, 120/1/60, ODP Motor with thermal overload. Provide duct connections to suit.
- .2 Acceptable Product: "Delhi" Model 409

2.2 EXHAUST FANS (EF-4)

- .1 Centrifugal belt drive roof exhaust fan to match the existing exhaust fan, rated for 283 L/s @ 62Pa (600 CFM @ .25" ESP), ¼ HP, 120/1/60, ODP Motor with thermal overload. Provide roof curb and duct connections to suit.
- .2 Acceptable Product: "Delhi" Model: 307

HVAC FANS

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 FAN INSTALLATION

- .1 Install fans as indicated, complete with flexible electrical leads and flexible connections.
- .2 Provide sheaves and belts required for final air balance.
- .3 Bearings and extension tubes to be easily accessible.
- .4 Access doors and access panels to be easily accessible.

3.3 CLEANING

- .1 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

LOUVRES, INTAKES AND VENTS

Part 1 General

1.1 SUMMARY

.1 Section Includes:

- .1 Mechanical louvers; intakes; vents; and reinforcement and bracing for air vents, intakes and gooseneck hoods.

1.2 REFERENCES

.1 American National Standards Institute (ANSI)/ National Fire Protection Association (NFPA)

- .1 ANSI/NFPA 96-04, Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.

.2 American Society for Testing and Materials International (ASTM)

- .1 ASTM E90-04, Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements.

.3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)

- .1 Material Safety Data Sheets (MSDS).

.4 Sheet Metal and Air Conditioning Contractors' National Association (SMACNA)

.5 Society of Automotive Engineers (SAE)

1.3 SYSTEM DESCRIPTION

.1 Performance Requirements:

- .1 Catalogued or published ratings for manufactured items: obtained from tests carried out by manufacturer or those ordered by manufacturer from independent testing agency signifying adherence to codes and standards.

1.4 SUBMITTALS

.1 Product Data:

- .1 Submit manufacturer's printed product literature, specifications and datasheet in accordance with Section 01 33 00 - Submittal Procedures. Include product characteristics, performance criteria, and limitations.

- .2 Indicate following:

- .1 Pressure drop.
- .2 Face area.
- .3 Free area.

LOUVRES, INTAKES AND VENTS

Part 2 Products

2.1 FIXED LOUVRES - ALUMINUM

- .1 Construction: welded with exposed joints ground flush and smooth.
- .2 Material: extruded aluminum alloy.
- .3 Blade: stormproof pattern with centre watershed in blade, reinforcing bosses and maximum blade length of 1500 mm.
- .4 Frame, head, sill and jamb: 100 mm deep one piece extruded aluminum, minimum 3 mm thick with approved caulking slot, integral to unit.
- .5 Mullions: at 1500 mm maximum centres.
- .6 Fastenings: stainless steel SAE-194-8F with SAE-194-SFB nuts and resilient neoprene washers between aluminum and head of bolt, or between nut, ss washer and aluminum body.
- .7 Screen: 19 mm intake mesh, 2 mm diameter wire aluminum birdscreen on inside face of louvres in formed U-frame.
- .8 Finish: factory applied enamel. Colour: to match existing exterior wall.
- .9 Acceptable Product: "E.H. Price" per louver schedule on drawings.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 In accordance with manufacturer's and SMACNA recommendations.
- .2 Reinforce and brace as indicated.
- .3 Anchor securely into opening. Seal with caulking to ensure weather tightness.

END OF SECTION

HEAT EXCHANGERS FOR HVAC

Part 1 General

1.1 SUMMARY

- .1 Section Includes:
 - .1 Materials and installation for piping and fittings used in HVAC heat exchangers.
- .2 Related Sections:
 - .1 Section 01 33 00 - Submittal Procedures.
 - .2 Section 01 78 00 - Closeout Submittals.
 - .3 Section 01 91 13 - Commissioning.

1.2 REFERENCES

- .1 American Society of Mechanical Engineers (ASME)
 - .1 ASME Boiler and Pressure Vessel Code.
 - .1 BPVC-VIII B-[2004], BPVC Section VIII - Rules for Construction of Pressure Vessels Division 1.
 - .2 BPVC-VIII-2 B-[2004], BPVC Section VIII - Rules for Construction of Pressure Vessels Division 2 - Alternative Rules.
 - .3 BPVC-VIII-3 B-[2004], BPVC Section VIII - Rules for Construction of Pressure Vessels Division 3 - Alternative Rules High Press Vessels.
- .2 Canadian Standards Association (CSA International)
 - .1 CSA B51-[03], Boiler, Pressure Vessel, and Pressure Piping Code.
- .3 Health Canada/Workplace Hazardous Materials Information System (WHMIS)
 - .1 Material Safety Data Sheets (MSDS).

1.3 SUBMITTALS

- .1 Submittals in accordance with Section 01 33 00 - Submittal Procedures.
- .2 Product Data:
 - .1 Submit manufacturer's printed product literature, specifications and datasheet for heat exchangers.
- .3 Shop Drawings:
 - .1 Submit shop drawings to indicate project layout including layout, dimensions of heat exchangers and system. Indicate following information:

HEAT EXCHANGERS FOR HVAC

- .1 Manufacturer's recommended clearances for tube withdrawal and manipulation of tube cleaning tools.
- .2 Test Reports: submit certified test reports from approved independent testing laboratories indicating compliance with specifications for specified performance characteristics and physical properties.
- .3 Certificates: submit certificates signed by manufacturer certifying that materials comply with specified performance characteristics and physical properties.
- .4 Instructions: submit manufacturer's installation instructions.
- .5 Manufacturer's Field Reports: manufacturer's field reports specified.
- .6 Closeout Submittals: submit maintenance and engineering data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.4 MAINTENANCE

- .1 Maintenance Materials:
 - .1 Provide maintenance materials in accordance with Section 01 78 00 - Closeout Submittals.
- .2 Supply following spare parts:
 - .1 Head gaskets.

Part 2 Products

2.1 TUBE-IN-SHELL HEAT EXCHANGER

- .1 General:
 - .1 Steam to 50% propylene glycol.
 - .2 Designed, constructed and tested in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, CSA B51 and provincial pressure vessel regulations.
- .2 Shell: steel 1034 kPa (150 psi) working pressure. NPT connections, sizes as indicated. Tappings for drain.
- .3 Head: cast iron NPT inlet and outlet. Tapped connections for drain and vacuum breaker.
- .4 Tubes: 20 mm o.d. (NPS 3/4 O.D.) copper, with brass tube support. Maximum tube velocity: 2.1 m/s (7.0 ft/s).
- .5 Tube sheet: steel
- .6 Fouling factor: 0.00022

HEAT EXCHANGERS FOR HVAC

- .7 Capacity:
 - .1 Shell side: 69 kPa (10 psi Steam), 0.088 L/s(1.4 usgpm).
 - .2 Tubeside: 50% propylene glycol, 4.42 L/s (70 usgpm) from 71°C (160°F) to 82°C (180°F), 185 kW (633,000 BTUH) heat output, 4.8 kPa (0.7 psi) pressure drop.
- .8 Working pressure: shall be 1034 kPa (150 psi), tubes 862 kPa (125 psi).
- .9 Dimensions: as indicated on drawings.
- .10 Mounting supports: steel or cast iron saddles.
- .11 Acceptable Product: Bell & Gossett SU 64-2.

Part 3 Execution

3.1 MANUFACTURER'S INSTRUCTIONS

- .1 Compliance: comply with manufacturer's written recommendations or specifications, including product technical bulletins, handling, storage and installation instructions, and datasheet.

3.2 INSTALLATION

- .1 General: install level and firmly anchored to supports [as indicated] [in accordance with manufacturer's recommendations].
- .2 Tube in shell heat exchangers: arrange piping so that tube bundle can be removed after disconnecting two unions or flanges adjacent to head and without disturbing other equipment and systems.
- .3 Plate exchangers: install in accordance with manufacturer's recommendations.

3.3 APPURTENANCES

- .1 Install with safety relief valve piped to drain and vacuum breaker.
- .2 Install thermometer wells with thermometers on inlet and outlet of secondary side.
- .3 Install pressure gauges on steam inlet.

3.4 DEMONSTRATION

- .1 Training: provide training in accordance with Section 01 91 13 - Commissioning: Training of O&M Personnel, supplemented as specified.

HEAT EXCHANGERS FOR HVAC

3.5 CLEANING

- .1 Perform cleaning operations in accordance with manufacturer's recommendations.
- .2 Upon completion and verification of performance of installation, remove surplus materials, excess materials, rubbish, tools and equipment.

END OF SECTION

AIR HANDLING UNITS

Part 1 General

1.1 SUMMARY

- .1 Supply, install, and commission air handling unit as specified herein.
- .2 Delivery lead time of the air handling units shall be not more than 12 weeks.

1.2 REFERENCES

- .1 American National Standards Institute/Air-Conditioning and Refrigeration Institute (ANSI/ARI)
 - .1 ANSI/ARI 430-99, Central Station Air Handling Units.
- .2 Canadian General Standards Board (CGSB)
 - .1 CAN/CGSB 1.181-99, Ready-Mixed Organic Zinc-Rich Coating.

1.3 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit shop drawings and product data in accordance with section 01 33 00.
- .2 Indicate following: fan, motor drive, voltage, dimensions, total cooling, sensible cooling; include performance data.

1.4 CLOSEOUT SUBMITTALS

- .1 Provide maintenance data for incorporation into manual specified in Section 01 78 00 - Closeout Submittals.

1.5 EXTRA MATERIALS

- .1 Provide list of individual manufacturer's recommended spare parts for equipment such as bearings and seals, and addresses of suppliers, together with list of specialized tools necessary for adjusting, repairing or replacing, for placement into operating manual.
- .2 Spare filters: in addition to filters installed immediately prior to acceptance by Contract Administrator, supply 5 complete sets of filters for each filter unit or filter bank.

Part 2 Products

2.1 SPLIT SYSTEM AIR HANDLING UNIT (AHU-1, 2/ CU-1, 2)

- .1 General:
 - .1 Factory assembled, split-system cooling unit. Contained within the unit enclosure shall be all factory wiring, piping, controls, and refrigerant charge (R-410A) and special features required prior to field start-up.
- .2 Unit Cabinet:

AIR HANDLING UNITS

- .1 Unit cabinet shall be constructed of galvanized steel construction, and shall be bonderized and coated with prepainted baked enamel finish on all externally exposed surfaces.
- .2 Evaporator fan compartment interior cabinet surfaces shall be insulated with a minimum 13mm thick, flexible fibreglass insulation, neoprene coated on the air side.
- .3 Cabinet panels shall be removable for servicing.
- .4 Unit shall have a factory-installed, sloped condensate drain pan made of a non-corrosive material, providing a minimum 19mm (3/4"NPT) connection.
- .5 Unit shall have a factory-installed filter access panel.
- .3 Fans:
 - .1 Evaporator Fan:
 - .1 Fan shall be belt driven, c/w adjustable-pitch motor pulley.
 - .2 Fan wheel shall be double-inlet type with forward-curved blades.
 - .3 Bearing shall be sealed, permanently lubricated ball bearing type.
 - .4 Fan shall be made from steel with corrosion-resistant finish, statically and dynamically balanced.
 - .2 Condenser fan shall be direct driven, totally enclosed motors, propeller type, and shall discharge air vertically. Condenser fan shall have aluminum blades riveted to corrosion-resistant steel spiders, and shall be dynamically balanced.
- .4 Coils:
 - .1 Evaporator and Condenser Coils shall have aluminum lanced plate fins mechanically bonded to seamless internally grooved copper tubes, brazed joints.
 - .2 Testing:
 - .1 Qualified to UL 1995 burst test at 15168 kPa (2200 PSI).
 - .2 Leak tested to 1034 (150 PSIG), pressure test to 2758 kPa (400 PSIG).
- .5 Refrigerant Components shall include:
 - .1 Fixed orifice metering system.
 - .2 Refrigerant filter drier.
 - .3 Service gage connections on suction, discharge, and liquid lines.
- .6 Filter Section:
 - .1 Factory-installed, low velocity, throwaway 50mm (2") thick fibreglass filters, commercially available sizes, use one size filter.
 - .2 Filter face velocity shall not exceed 1.6 m/s (320 FPM) at nominal airflows.
 - .3 Filters shall be accessible through access panel with "no-tool" removal.
- .7 Controls and Safeties:
 - .1 Unit shall be complete with self-contained low-voltage control circuit protected by a fuse on the 24-V transformer side.

AIR HANDLING UNITS

- .2 Unit shall incorporate a solid state compressor protector which provides anti-cycle reset capability at the space thermostat, should any of the following standard safety devices trip and shut off compressor.
 - .1 Compressor over temperature, overcurrent.
 - .2 Loss-of-charge/low-pressure switch.
 - .3 Freeze-protection thermostat, evaporator coil.
 - .4 High-pressure switch
 - .5 Automatic reset motor thermal overload protector.
- .8 Operating Characteristics:
 - .1 Unit shall be capable of starting and running at 52°C ambient outdoor temperature, meeting maximum load criteria of ARI Standard 210/240 or 360 at ±10% voltage.
- .9 Electrical:
 - .1 Unit voltage shall be 575V/3Ph/60Hz. All unit power wiring shall enter unit cabinet at a single factory-predrilled location.
- .10 Motors:
 - .1 Compressor Motors: cooled by refrigerant gas passing through motor windings, line break thermal and current overload protection.
 - .2 Evaporator-fan Motor: permanently lubricated bearings, inherent automatic-reset thermal overload protection. Motor(s) shall be VFD rated.
 - .3 Totally-enclosed Condenser-fan Motor: permanently lubricated bearings, inherent automatic-reset thermal overload protection.
- .11 Special Features:
 - .1 Roof Curbs: formed galvanized steel, wood nailer strip, capable of supporting entire unit weight.
- .12 Air Handling Unit Schedule:

AIR HANDLING UNITS

AIR HANDLING UNIT SCHEDULE				
FAN NO.		AHU-1	AHU-2	
SERVICE				
MANUFACTURER		Engineered Air	Engineered Air	
MODEL		LM4/C	LM8/C	
SUPPLY	L/S (CFM):	1888 (4,000)	3398 (7,200)	
	ESP ("WC):	1	1	
	MOTOR (HP):	5	7.5	
	BLOWER:	12/12	18/18	
RETURN	L/S (CFM):			
	ESP ("WC):			
	MOTOR (HP):			
	BLOWER:			
COOLING	EAT (DB/WB) (°F):	80/67	80/67	
	LAT (DB/WB) (°F):	58.1/57	58.7/57.4	
	TOTAL (BTU/H):	128.9	222.8	
	SUCTION (°F):	48.9	48.3	
HEATING	EAT (DB) (°F):	55	55	
	LAT (DB) (°F):	109	99	
	TOTAL (BTU/H):	234	345	
Dimensions (shall not be exceeded):		2895mm L x 1320 mm W x 990 mm H (114" L x 52" W x 39" H)	3352mm L x 1752mm W x 1194mm H (132" L x 69" W x 47" H)	
Balance with Condenser Model:		CUEA112	CUEB182	

Part 3 Execution

3.1 INSTALLATION

- .1 Provide appropriate protection apparatus.
- .2 Install units in accordance with manufacturer's instructions and as indicated.
- .3 Ensure adequate clearance for servicing and maintenance.

3.2 FANS

- .1 Provide fan sheaves required for final air balance.

END OF SECTION