

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide a complete automatic sprinkler system, including all necessary labour services, products, materials and equipment as shown on the Drawings and as specified herein. Products, materials and equipment shall include, but not necessarily be limited to, the following:
 - .1 Piping and fittings.
 - .2 Valves.
 - .3 Hydraulic piping design and calculations.
 - .4 Sprinkler heads.
 - .5 Sprinkler cabinets.
 - .6 Supervisory devices.
 - .7 Hydrant water flow tests required for hydraulic design.

1.2 REFERENCE STANDARDS

- .1 Provide all work in accordance with the latest requirements of NFPA 13, local codes and all authorities having jurisdiction.
- .2 Provide materials that are ULC listed and approved.

1.3 SUBMITTALS

- .1 Prior to installation, submit minimum ten (10) copies of the working drawings, hydraulic design and calculations to all authorities having jurisdiction. All hydraulic design and calculations shall be sealed by a professional engineer. Assume any additional costs that may be incurred to modify or complete the system should the authorities having jurisdiction require changes. Any and all costs pertaining to approval shall be borne by the Contractor.
- .2 Submit Drawings to the Consultant after review by all authorities having jurisdiction including comments received.
- .3 Provide shop drawings for all sprinkler hardware including heads, alarm valves and trim, valves.

1.4 SAMPLES

- .1 Provide samples of each type of sprinkler head and accompanying escutcheons.
- .2 Provide samples of sprinkler head guards.

PART 2 - PRODUCTS

2.1 PIPE AND FITTINGS

- .1 Provide pipe and fittings of good quality consistent with the respective manufacturer, devoid of any defects and compatible with required system working pressure.
- .2 All sprinkler piping shall be rigid black steel pipe, including piping connections to sprinkler heads. Flexible sprinkler drops are not permitted on sprinkler head connections.
- .3 Pipe sizes up to 150 mm (6") shall be Schedule 40 black steel pipe conforming to ASTM standards. Thin wall piping conforming to ASTM standards is acceptable when used with rolled groove fittings for plain end pipe.
- .4 Pipe sizes 200 mm (8") and over shall be Schedule 30 black steel pipe conforming to ASTM standards.
- .5 Connections shall be screwed for piping 65 mm (2-1/2") and under. Connections for piping over 65 mm (2-1/2") may be screwed, welded (when approved by local authorities) or joined by means of Victaulic couplings (when approved by local authorities and performed to NFPA and IAO standards).
- .6 Victaulic types fittings shall only be used where piping is accessible.

2.2 SPRINKLER HEADS

- .1 Provide ULC approved sprinkler heads:
 - .1 In finished ceilings, unless otherwise indicated, chrome plated semi-recessed liquid filled pendant heads with chrome plated or painted escutcheons.
 - .2 In finished ceilings, where specifically indicated, fully recessed sprinkler heads (flush type) with painted or stainless steel coverplates.
 - .3 In unfinished areas, (such as mechanical rooms, garage, etc.) pendant or upright bronze sprinkler heads.
- .2 Provide wire guards to protect sprinkler heads in all mechanical, electrical and elevator machine rooms, and in any area where heads may be damaged.

- .3 Provide high temperature sprinkler heads in electric rooms, elevator machine rooms, diesel generator rooms, boiler rooms, and in all locations where sprinkler heads are located close to heating coils, unit heaters, high-intensity lighting or other hot equipment.
- .4 Provide a metal cabinet with spare sprinkler heads of each type, 5 spare wrenches, keys and labels. Locate the cabinet in an accessible location in the 4th floor mechanical room.
- .5 Rooms or spaces having dropped ceilings that are open to the surrounding areas shall have sprinkler coverage provided both above and below the dropped ceiling as required by NFPA 13. The Drawings indicate only the sprinkler heads to be installed below the dropped ceiling areas. Provide sprinkler coverage above the dropped ceilings in accordance with NFPA 13.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Piping and Fittings

- .1 Install piping and fittings, including all necessary hangers and supports, in accordance with NFPA and IAO regulations, codes and all authorities having jurisdiction.
- .2 Flush the piping system until all foreign material has been removed. Provide a certificate stating that proper flushing has been performed.
- .3 Provide a system test for two (2) hours at 1780 kPA (250 psi) without any pressure loss. If leaks occur, they shall be repaired and the system retested. Provide a certificate stating that the hydrostatic test has been carried out to the satisfaction of all authorities having jurisdiction.
- .4 In areas with floating ceilings or with ceiling projections, sprinkler piping shall be concealed behind adjacent walls, ceiling spaces, structural elements, etc. so as not to be visible. All piping drops for these areas shall be concealed in such a manner. Horizontal piping serving sprinkler heads shall be installed at low level as close to the top of the floating ceiling or ceiling projection as possible so as not to be visible.

3.2 PERMITS AND INSPECTIONS

- .1 Apply and pay for all necessary permits and inspections required by authorities having jurisdiction.

3.3 HYDRAULIC DESIGN CRITERIA

- .1 Provide hydraulically designed system in accordance with NFPA 13 standards.

- .2 Provide the hydraulic design and piping calculations necessary for a complete sprinkler system.
- .3 Hazard classification shall be to NFPA 13 (IAO G13) standards:
 - .1 Office areas - light hazard.
- .4 Provide and install the required number of sprinkler heads and all necessary components as approved by all codes and all governing authorities.

END OF SECTION

PART 1 – GENERAL

1.1 General

- .1 The purpose of this section is to specify Division 22 responsibilities in the commissioning process.
- .2 The systems to be commissioned are listed in Section 01 91 00.1.9.
- .3 Commissioning requires the participation of Division 22 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. Division 22 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 Responsibilities

- .1 Plumbing Contractor: The responsibilities of the Plumbing Contractor, during construction and acceptance phases in addition to those listed above are (all references apply to commissioned equipment only):
 - .1 Documentation of all procedures performed shall be provided and forwarded to the Consultant. Written documentation must contain recorded test values of all tests performed per the individual product specification.
 - .2 The start-up service company shall be present during energization of the plumbing equipment. Site and equipment access must be provided by the plumbing Subcontractor.
 - .3 The Contractor shall supply a power source, specified by the start-up service company, for on-Site test equipment.
 - .4 The plumbing Subcontractor is to attend all factory witness testing required within the respective Specification sections. The Contractor is responsible to cover all their costs and include them in their bid.
 - .5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
 - .6 Include the cost of commissioning in the Contract Price, if not yet included.
 - .7 In each purchase order or subcontract written, include requirements for submittal data, Operating and Maintenance (O&M) data and training.
 - .8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.
 - .9 Contractor shall provide normal cut sheets and Shop Drawing submittals to the CA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of pre-functional and functional testing procedures.
 - .1 Typically this will include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan and pump curves, full factory testing reports, if any, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.
 - .2 The Commissioning Agent may request further documentation necessary for the commissioning process. This data request may be made prior to normal submittals.

- .10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review.
- .11 Contractors shall assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the Specifications, control Drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- .12 Provide assistance to the CA in preparation of the specific functional performance test procedures specified in Section 22. Subcontractors shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- .13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
- .14 During the startup and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CA for all commissioned equipment.
- .15 Perform and clearly document all completed startup and system operational checkout procedures, providing a copy to the CA.
- .16 Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
- .17 Perform functional performance testing under the direction of the CA for specified equipment in Section 01 91 00, subsection 1.9. Assist the CA in interpreting the monitoring data, as necessary.
- .18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, PM and A/E and retest the equipment.
- .19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- .20 During construction, maintain as-built red-line Drawings for all Drawings and final CAD as-builts for Contractor-generated coordination Drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built Drawings for all Drawings and final as-builts for Contractor-generated coordination Drawings
- .21 Provide training of the Owner's operating personnel as specified in Section 25 00 00.
- .22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- .23 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the Specifications.
- .24 Correct deficiencies and make necessary adjustments to O&M manuals and as-built Drawings for applicable issues identified in any seasonal testing.
- .25 Assist and cooperate with the mechanical and Testing, Adjusting Balancing (TAB) Subcontractor and CA by:
 - .1 Putting all equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
 - .2 Providing temperature and pressure taps according to the Contract Documents for TAB and commissioning testing.

- .26 Install a Pressure Transducer (P/T) plug at each water sensor which is an input point to the control system.
- .27 List and clearly identify on the as-built Drawings the locations of applicable sensors and meters
- .28 Prepare a preliminary schedule, in conjunction with Division 25 Subcontractors for Division 22 pipe system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
- .29 Notify the PM/GC or CA depending on protocol, when pipe system testing, flushing, cleaning, start-up of each piece of equipment and TAB will occur. Be responsible to notify the PM/GC or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed, and that the CA has the scheduling information needed to efficiently execute the commissioning process.

PART 2 - PRODUCTS

- .1 NOT USED

PART 3 - EXECUTION

3.1 Submittals

- .1 The Contractor shall ensure that Section 22 Subcontractors provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 22 requirements.

3.2 Start-up of Equipment

- .1 The plumbing Subcontractors shall follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 00. Division 22 has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.
- .2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment the Division 22 Contractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The Supplier shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the manufacturer's recommendations the equipment may be started.
- .6 All equipment shall be started by the manufacturer's representative.

3.3 Pre-Functional Test Sheets

- .1 Pre-functional test sheets contain items for Section 22 Subcontractors to perform. On each checklist, a column is provided that is to be completed by the Contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the form. If this form is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their Subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = all Contractors, CA = Commissioning Agent, CC = Controls Contractor, EC = Electrical Contractor, PM/GC = General Contractor, MC = Mechanical Contractor, SC = Sheet Metal Contractor, TAB = Test and Balance Contractor.

3.4 Operations and Maintenance Manuals

- .1 The Contractor shall ensure that Section 22 Subcontractors compile and prepare documentation for all equipment and systems covered in Section 22 and deliver to the Contractor for inclusion in the O&M manuals.
- .2 The CA shall receive a copy of the O&M manuals for review.

3.5 Training of Owner Personnel

- .1 The Contractor shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.
- .3 Mechanical Contractor. The mechanical contractor shall have the following training responsibilities:
 - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
 - .2 Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.
 - .3 Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, fire/smoke alarm, power failure, etc.
 - .4 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.

- .5 The appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
- .6 The controls Subcontractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
- .7 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
- .8 Training shall include:
 - .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - .2 A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - .3 Discussion of relevant health and safety issues and concerns.
 - .4 Discussion of warranties and guarantees.
 - .5 Common troubleshooting problems and solutions.
 - .6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
 - .7 Discussion of any peculiarities of equipment installation or operation.
- .9 The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 1-1989R, 1996 is recommended.
- .10 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- .11 Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
- .12 The mechanical Subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .13 Training shall occur after functional testing is complete, unless approved otherwise by the Consultant.

3.6 Deferred Testing

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

3.7 WRITTEN WORK PRODUCTS

- .1 The Contractor shall ensure that written work products of Section 22 Subcontractors consist of the start-up and initial checkout plan as described in Section 01 91 00, as well as completed start-up, initial checkout and pre-functional test sheets.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

.1 Provide complete plumbing and drainage systems, including all necessary labour, services, Products, materials and equipment as shown on the Drawings and listed in the schedules as specified herein. Products, materials and equipment shall include, but not necessarily be limited to, the following:

.1 Piping and fittings.

.2 Valves.

1.2 REFERENCE STANDARDS

.1 Provide all Work in accordance with the latest edition of the Ontario Plumbing Code and the requirements of all local Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc., and all applicable by-laws.

1.3 SUBMITTALS

.1 Submit Shop Drawings for each type of valve in accordance with Section 21 05 01.

.2 Submit Shop Drawings for grooved mechanical couplings and fittings in accordance with Section 21 05 01.

.3 Provide valve charts for inclusion in Operating and Maintenance Manuals in accordance with Section 21 05 01.

PART 2 - PRODUCTS

2.1 PLUMBING PIPING AND FITTINGS

.1 Provide pipe and fittings of good quality devoid of any defects and compatible with required system working pressure.

1 Domestic Water Piping

1 Above Ground - 100 mm (4") and smaller.

1 Type 'L' hard copper pipe with wrought copper fittings and silver solder joints.

2 Sanitary Drain and Vent Piping.

1 Above Ground - 65 mm (2-1/2") and smaller.

1 Drain, Waste, Vent ("DWV") copper with drainage fittings and 60/40 lead/tin solder joints.

- 2 Plastic drain, waste and vent piping is acceptable for use above grade provided it meets the minimum requirements for flame spread (25) and smoke developed (50) classifications as required by the Ontario Building Code (i.e. IPEX XFR or Equivalent).
- 2 Above Ground - 75 mm (3") and larger.
 - 1 CSA class 4000 cast iron soil piping and drainage fittings.
 - 2 Plastic drain, waste and vent piping is acceptable for use above grade provided it meets the minimum requirements for flame spread (25) and smoke developed (50) classifications as required by the Ontario Building Code (i.e. IPEX XFR or Equivalent).

2.2 VALVES

- .1 Provide valves that are compatible with the piping and service required.
- .2 Valves of each type shall be the product of one manufacturer.

2.3 WATER HAMMER ARRESTORS (SHOCK STOPS)

- .1 Provide pre-charged hard drawn copper shock absorber with brass piston, Ethylene Propylene Diene Monomer ("EPDM") O-ring seals and make IPS (Iron Pipe Size) connection.
- .2 Suitable for pressures up to 150 psi, and temperatures to 180 F.
- .3 Unit sizing as per manufacturers instructions. Confirm following sizing table with manufacturer, use manufacturers sizing guidelines.

FIXTURE UNITS	ARRESTOR SIZING
1-11	CONNECTION: 1/2", HEIGHT: 5" DIAMETER: 1-7/16"
12-32	CONNECTION: 3/4", HEIGHT: 7" DIAMETER: 1-7/16"
33-60	CONNECTION: 1", HEIGHT: , 7-3/8" DIAMETER: 2-3/16"
61-113	CONNECTION: 1-1/4", HEIGHT: 10-13/16" DIAMETER: 2-11/16"
114-154	CONNECTION: 1-1/2", HEIGHT: 1-1/2" DIAMETER: 3-5/16"
155-330	CONNECTION: 2", HEIGHT: 14-7/8" DIAMETER: 3-5/16"

2.4 PLUMBING VALVE SCHEDULE

PLUMBING VALVE SCHEDULE				
SYSTEM	PIPING	TYPE	SYSTEMS 50 MM (2") AND SMALLER	SYSTEMS 65 MM (2-1/2") AND LARGER
Domestic	Copper	Gate	Bronze, soldered, solid wedge disc, NRS, 200 psi CWP. (1324) Kitz #64	Iron body, flanged, solid wedge disc, O.S.&Y. bronze trim, RS 200 psi CWP. (465-1/2) Kitz#72 Toyo #421A
Domestic	Copper	Globe	Bronze, soldered, renewable teflon disc, 200 psi CWP. (1310) Kitz#10 Toyo #222	Iron body, flanged O.S.&Y., bronze trim, 200 psi CWP. (351) Kitz #76 Toyo#400A
Domestic	Copper	Ball (*)	Kitz#69AMLL Toyo#5049S MAS B3ZSS * Note Lock and Lever	2-1/2" and 3" same as 2" and smaller but 400 psi CWP.
Domestic	Copper	Butterfly (Lug Wafer Type)	Note: Butterfly valves shall be lugged type, cast Iron or Ductile iron body, Aluminum bronze disc, EPDM liner, stainless steel stem. Valves shall have bubble tight shutoff to 200psi when downstream flange is removed (Full dead-end service valves. 150mm (6") smaller shall have lever operator. Valves 200mm (8") & Larger shall have manual gear operator.	Iron body, flanged, anti-friction coated ductile iron disc, 416 stainless steel stem, EPDM seat, 150 psi CWP. 4" & Less: lock lever handles. 6" & greater: gear operator with handwheel (55-D4E) Kitz 6122EL (Lever) Kitz 6122EG (Gear) Toyo 918BESL (Lever) Toyo 918BESG (Gear) Demco NE Series 22XX5-1145351(285PSIG)
Domestic	Copper	Check	Bronze, soldered, swing, Y pattern 200 psi CWP. Kitz#30.	2-1/2" and 3" same as 2" and smaller. Kitz#30.
<p>NOTES:</p> <p>1. (*) For drain valves, provide complete with hose end adaptor, cap and chain.</p> <p>2. Valves based on Crane Manufacturer</p> <p><input type="checkbox"/> RS = Rising Stem</p> <p><input type="checkbox"/> NRS = Non-Rising Stem</p>				

PART 3 – EXECUTION

3.1 TESTING OF DOMESTIC WATER PIPING SYSTEMS

- .1 When piping system installation is complete, pressure test all domestic water piping systems as required by the Ontario Building Code.
- .2 Provide water pressure test or air pressure test. Water pressure testing shall confirm that piping systems withstand a water pressure of minimum 1000 kPa (145 psi) for minimum 1 hour with no loss of pressure. Air pressure testing shall confirm that piping system withstands an air pressure of minimum 700 kPa (102 psi) for minimum 2 hour with no drop in air pressure.

3.2 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- .1 Prior to starting Work, verify system is complete, flushed and clean. Ensure PH of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- .2 Inject disinfectant, free chlorine in liquid, powder, tablet or gas form, throughout system to obtain 50 to 80 mg/l residual.
- .3 Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets. Maintain disinfectant in system for 24 hours. If final disinfectant residual tests less than 25 mg/L, repeat treatment.
- .4 Flush disinfectant from system until residual equal to that of incoming water or 1.0 mg/L. Take samples no sooner than 24 hours after flushing, from 5 percent of outlets and from water entry, and analyze.

3.2 INSTALLATION

- .1 Piping and Fittings
 - 1 Install piping such that uniform grade is maintained. Install piping with ends aligned and carefully abutted. Install pipe joints in accordance with the recommendations of the respective manufacturer.
 - 2 Ensure that the piping is protected at all times from movement, etc. Ensure piping is kept clean at all times and cap ends during periods when work is stopped.
 - 3 Install piping to conform to building planes. Run parallel to walls and structural components. Conserve headroom at all times and co-ordinate the piping installation with the Work of other Subcontractors and Divisions.
 - 4 Install flanges or unions to isolate each piece of equipment.
 - 5 Provide the necessary chemicals, equipment and labour to clean and disinfect the system to the requirements of all Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc.

.2 Valves

- 1 Install valves at each piece of equipment, plumbing fixture, at the base of each riser and at any main branch of the piping system.

.3 Water Hammer Arrestors

- 1 Install arrestors concealed inside partitions.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide complete plumbing and drainage systems, including all necessary labour, services, products, materials and equipment as shown on the Drawings, listed in the equipment schedules on the mechanical Drawings and as specified herein. Products, materials and equipment shall include, but not necessarily be limited to, the following:
 - .1 Floor drains;
 - .2 Cleanouts;
 - .3 Miscellaneous plumbing specialties.

1.2 REFERENCE STANDARDS

- .1 Provide all Work in accordance with the latest edition of the Ontario Building Code and the requirements of all local Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc., and all applicable by-laws.

PART 2 - PRODUCTS

2.2 FLOOR AND ROOF DRAINS

- .1 Provide all floor drains necessary for a complete installation.
- .2 Refer to equipment schedules for details.

2.3 CLEANOUTS AND MISCELLANEOUS

- .1 Provide all cleanouts and miscellaneous items necessary for a complete installation.
- .2 Refer to equipment schedules for details.

2.4 THERMOSTATIC MIXING VALVES

- .1 Complete with check valve, volume control shut-off valve and stem thermometer on outlet, strainer stop check on inlet, mounted in lockable cabinet of 1.5 mm prime coated steel.

2.5 TRAP SEAL PRIMERS

- 1. Provide trap seal primers for all floor drains including all necessary piping and appurtenances and connect to nearest available domestic cold water supply in accordance with local Authority standards, including but not limited to standards of the plans examiner, building inspector, etc.

PART 3 – EXECUTION

3.1 INSTALLATION

.1 Floor and Roof Drains

- 1 Install floor drains as required by the Ontario Building Code (“OBC”) and as detailed on the Drawings.
- 2 Install roof drains as required by OBC and as detailed on the Drawings.

.2 Cleanouts and Miscellaneous

- 1 Install cleanouts in sanitary and storm drainage piping as required by OBC and all Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc.
- 2 Install cleanouts at the base of all stacks and at each major change of direction on horizontal pipe runs.
- 3 Install backflow preventors on all domestic water connections to non-potable water systems. Pipe all relief ports to nearest funnel floor drain.

.3 Trap Primers

- 1 Install in accordance with manufacturers’ recommendations.
- 2 Connect to nearest available domestic cold water supply in accordance with local Authority standards, including but not limited to standards of the plans examiner, building inspector, etc.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide plumbing fixtures and trim as listed in the equipment schedules where shown on the Drawings.

1.2 REFERENCE STANDARDS

- .1 Perform all Work in accordance with the latest edition of the Ontario Building Code and the requirements of all local Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc., and all applicable by-laws.

PART 2 - PRODUCTS

2.1 PLUMBING FIXTURES AND TRIM

- .1 Provide all plumbing fixtures and trim, including traps, wastes, water connections, etc. necessary for a complete and functional installation.
- .2 Plumbing fixtures and trim shall be Products of one manufacturer unless otherwise noted in the Contract Documents or approved by the Consultant.
- .3 Plumbing fixtures shall be white unless otherwise noted in the Contract Documents.
- .4 All plumbing fixtures and trim shall conform to the latest CSA standards.
- .5 Refer to equipment schedules for details.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install new plumbing fixtures and trim. Finished surfaces shall be clean, smooth and bright, and guaranteed not to change colour nor to scale. Imperfections of any kind shall be sufficient reason for rejection by the Consultant and an acceptable replacement shall be installed at no extra cost to the Owner.
- .2 Provide cast brass, chrome plated escutcheon plates with set screws on all water and drain pipes passing through walls, floors and partitions.
- .3 Plumbing fixture mounting heights to comply with NBCC and CSA B651 Standards.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Division 26 ELECTRICAL includes the provision of power wiring from motor starters to motors.
- .2 Division 26 ELECTRICAL includes the provision of power wiring from electrical panels or splitters to loose motor starters.
- .3 Division 26 ELECTRICAL includes the provision of power wiring from electrical panels or splitters to packaged control panels.
- .4 Division 23 CONTROLS includes the provision of interlock wiring between motor starters.
- .5 Division 23 CONTROLS includes the provision of control wiring from motor starters to remote control devices.
- .6 Division 23 CONTROLS includes the provision of control wiring from packaged control panels to remote control devices.
- .7 Division 23 CONTROLS includes the provision of control wiring for fire alarm fan shutdown from loose fan motor starters to fan shutdown relay in the nearest motor control centre.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Provide all wiring materials in accordance with the requirements of Division 26.
- .1 Wiring materials include, but are not limited to, conduit, wire, outlet boxes and wiring devices.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install all wiring in accordance with the requirements of the Electrical Safety Code (CSA C-22.1).
- .2 Install all control wiring in conduit. Conceal conduit where possible if not already placed in poured concrete.
- .3 The work of Division 26 ELECTRICAL includes provision of unfused disconnect switches for all motors supplied under this Division and where required by the Electrical Safety Code(CSA C-22.1).

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

.1 Provide complete systems, including all necessary labour, services, products, materials and equipment as shown on the Drawings, listed in the Schedules below, and as specified in the Contract Documents. Products shall include, but not necessarily be limited to, the following:

.1 Pipe and fittings.

.2 Valves

1.2 WORK PROVIDED BY OTHERS

.1 Automatic control valves shall be supplied under Section 25 00 00 Controls and installed as part of the work of this Section.

.2 Thermowells shall be supplied under Section 25 00 00 Controls and installed as part of the work of this Section.

1.3 REFERENCE STANDARDS

.1 Provide all work in accordance with the latest applicable codes of CSA and ASTM and the requirements of all local Authorities Having Jurisdiction, including plans examiner, building inspector, and all applicable by-laws.

PART 2 - PRODUCTS

2.1 PIPING AND FITTINGS

.1 Provide pipe and fittings of good quality devoid of any defects and in compliance with the latest ASTM regulations and standards.

.2 Heating Water

1 Schedule 40 black steel.

2 Type 'L' copper.

.3 Condensate Drains

1 DWV copper.

.4 Refer to Schedules below for fittings and methods of joining.

2.2 VALVES

.1 Provide valves that are compatible with the piping and service required.

.2 Valves of each type shall be the product of one manufacturer.

.3 Refer to Schedules below and to Section 23 05 15 for details.

2.3 THERMOWELLS

.1 Install thermowells supplied by controls Subcontractor where applicable. Coordinate locations with control Subcontractor.

2.4 HVAC VALVE SCHEDULE

SYSTEM	PIPING	TYPE	SYSTEMS 50 MM (2") AND SMALLER	SYSTEMS 65 MM (2-1/2") AND LARGER
		Swing Check	Bronze, threaded, swing disc, Y pattern, 200 psi CWP. Similar to Crane #37, Kitz #22, Toyo #236 or Equivalent	
		Silent Check		Install at discharge of pumps in vertical pipes. Cast iron body, wafer type, 316 SS disc and seat, BUNH-N ring and teflon spacer, Class 125. Similar to Grinnell or Equivalent.
		Circuit Balancing Valve (CBV)	Bronze copper alloy construction, threaded, teflon disc ring, 'Y' globe style, c/w hand wheel, division ring scale, drain connection & balancing connector ports with square knob shut-offs. Armstrong CBV I.	Cast iron construction, flanged teflon disc ring, 'Y' globe style c/w hand wheel, division ring scale, balancing connector ports with square knob shut-offs. Armstrong CBV II or Equivalent.
		Eccentric Plug		Cast iron construction, flanged or Victaulic, gear operator with handwheel. Similar to DeZurik Series 100 or Equivalent.
		Angle type combination shut off, balancing and check valve.		Install at discharge of vertical inline pumps. Flanged cast iron body, bronze disc and seat, SS stem and SS spring, multiple turn. Armstrong FTA or Equivalent.
NOTES:				
SS	Stainless Steel	RS	Rising Stem	NRS Non-Rising Stem

2.5 PIPE JOINTS AND FITTINGS SCHEDULE

PIPE JOINTS AND FITTINGS					
MATERIAL	TYPE			FLANGED	UNIONS
	MECHANICAL	SCREWED	WELDED		
Steel	Provide long radius elbow, malleable iron steel or ductile iron with wall thickness compatible with pipe. Victaulic fitting suitable for groove end pipe for chilled, condensor, glycol and hot water system.	Screwed permitted for all systems 50 mm (2") and under.	Weld all pipe sizes and provide long radius elbows and forged steel fittings of the same weight as the pipe being joined. Provide welding tees threadlets and weldlets on branch connections.	Weld neck or slip on with raised face.	Cast iron with ground joint.
Copper	Cast brass or streamline wrought copper. Provide dielectric fittings when connecting to steel pipe. Braze copper pipe and joints with 95/5 tine/antimony for water systems. For non-pressure drain systems solder with 50/50 tin/lead.			Cast brass or streamline wrought copper. Provide dielectric isolator when connecting to steel.	Cast iron with ground joint. Provide dielectric isolator when connecting to copper.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Piping and Fittings

- 1 Install piping with ends aligned and carefully abutted. Install pipe joints and fittings in accordance with the recommendations of the respective manufacturer, compatible with the operating pressure of the piping system and in conformance with the latest ANSI standards.
- 2 Ensure that the piping is protected at all times from movement, etc. Ensure piping is kept clean at all times and cap ends during periods when work is stopped.
- 3 Ensure that piping is cut true, reamed and cleaned before installation.
- 4 Ensure that piping and fittings are cleaned, bevelled, aligned and spaced prior to welding.
- 5 Install piping to conform to building planes. Run parallel to walls and structural components. Conserve headroom at all times and co-ordinate the piping installation with the work of other Subcontractor and Divisions.

- 6 Install flanges or unions at all connections to equipment. Ensure that all piping, fittings, valves and cleanout devices are accessible.
 - 7 Install a minimum of three (3) elbows at all branch connections or provide a flexible connection.
 - 8 Upfeed branches for heating by means of 45 degree to vertical, then grade up to riser or rise up vertically. Downfeed branches for heating by means of 45degree to vertical, then grade down to vertical drop or drop down vertically.
 - 9 Minimum grade for heating mains and branch supply: 1:50 up in direction of flow and on the return mains and branches grade 1:50 down in direction of flow.
 - 10 Install drain connections as required. Pipe discharge from safety valves, relief valves, overflows, etc., to nearest funnel floor drain.
 - 11 Provide drains at all low points in piping systems terminating with a plugged gate valve.
 - 12 Risers shall be valved where they connect to the mains, and in addition supply and install 20 mm (3/4") drain valves with hose end at the base of all risers.
 - .13 Provide the necessary chemicals, equipment and labour to clean and disinfect the system to the requirements of all Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector.
 - .14 Victaulic pipe fittings shall not be permitted in inaccessible spaces.
- .2 Valves
- 1 Install valves at each piece of equipment and where noted on the Drawings.

3.2 WELDING

- .1 All welding shall be performed by a certified welder holding a current certificate for the class of pipe to be welded.
- .2 Provide all welding and fabrication in accordance with current CSA standards and all Authorities Having Jurisdiction.
- .3 Provide adequate fire protection during welding or cutting procedures. Provide welder with a fully charged 10 lb CO² fire extinguisher for emergency use.
- .4 Provide York Region project manager a minimum advance notice of three Working Days prior to welding activities to ensure by-pass of existing smoke detectors prior to welding.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 The Contractor shall supply and install all motor starters for all motors supplied under this Division.
- .2 The Contractor shall supply and install all variable speed drives for motors supplied under this Division.

1.2 SUBMITTALS

- .1 Submit Shop Drawings for all variable speed drives in accordance with Section 21 05 01 and including individual schematic wiring diagrams for each starter, including the following data:
 - .1 EEMAC starter size.
 - .2 Fuse sizes.
 - .3 Control transformer size.
 - .4 Terminations for remote devices.
 - .5 Interlocking.
 - .6 Identification of all control components.
- .2 Submit revised updated shop drawings for inclusion in the project Operating and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 All starters shall be provided by the same manufacturer.
- .2 Identify all starters with lamacoid nameplates indicating equipment designation and service.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install starters, connect wiring as required.
- .2 Ensure correct fuses and overload heater elements are installed.

3.2 TESTING

- .1 Field test all starter's after completion of the wiring to verify correct operation.

END OF SECTION

PART 1 - GENERAL

1.1 SHOP DRAWINGS

- .1 Submit Shop Drawings in accordance with Section 21 05 01.
- .2 Indicate on manufacturer's catalogue literature: expansion tanks, air vents, separators, valves, strainers, and flow meters.

1.2 MAINTENANCE DATA

- .1 Provide maintenance data for incorporation into Operation and Maintenance Manuals.

PART 2 - PRODUCTS

2.1 AUTOMATIC AIR VENT

- .1 Standard float vent with brass body and NPS 1/8 connection and rated at 690 kPa (100 psi) working pressure.
- .2 Industrial float vent with cast iron body and NPS 1/2 connection and rated at 860 kPa (125 psi) working pressure.
- .3 Float: solid material suitable for 115 degrees C (240 degrees F) working temperature.

2.2 PIPE LINE STRAINER

- .1 NPS 1/2 - 2: bronze body, screwed connections.
- .2 NPS 2-1/2 - 12: cast steel body, flanged connections.
- .3 Size: as indicated on the Drawings.
- .4 Blowdown connection: NPS 1.
- .5 Screen: stainless steel with perforation size of 1.6 mm (1/16") to 75 mm (3") and 3.2 mm (1/8") for 100 mm (4") and larger.
- .6 Working pressure: 860 kPa (125 psi).

2.3 CIRCUIT BALANCING VALVES (CBV'S)

- .1 Each valve shall have two 1\4" NPT brass metering ports with check valves and gasketed caps located on both sides of valve seat. Two additional 1/4" NPT connections with brass plugs are to be provided on the opposite side of the metering ports for use as drain connections. Drain connections and metering ports are to be interchangeable to allow for measurement flexibility when valves are installed in tight locations.
- .2 Valves are to be of the "Y" pattern, modified, equal percentage globe style and shall provide the following

- three functions:
- 1 Precise flow measurement.
 - 2 Precision flow balancing.
 - 3 Positive drip tight shut off.
- .3 Valve shall provide multi-turn, 360° adjustment with a micrometer type indicator located on valve handwheel. Valve handwheel shall have hidden memory feature, which will provide a means for locking the valve position after the system is balanced. 90° turn adjustable valves are not acceptable.
 - .4 Valve body for 1/2" - 2" valves shall be bronze with ultra-high strength engineered resin plug. The plug shall have precision-contoured channels to distribute flow uniformly across valve seat. Bronze stem and high strength resin handwheel and sleeve. Valves shall have a minimum of four full 360° handwheel turns.
 - .5 Valve body for 2-1/2" - 12" valves shall be ductile iron with industrial standard grooved ends. Valve stem and plug disc shall be bronze with handwheel with multi-turn handwheel adjustments. Flange adapters shall be supplied, to prevent rotation.
 - .6 The valve shall be installed with flow in the direction of the arrow on the valve body and installed at least five pipe diameters downstream from any fitting, and at least ten pipe diameters downstream from any pump. Two pipe diameters downstream from the CBV shall be free of any fittings. Mounting of valve in piping must prevent sediment build-up in metering ports.
 - .7 Each valve shall be furnished with a pre-formed recoverable PVC insulation jacket to meet all required codes, including the Ontario Building Code, with a flame spread rating of 50 or less. Provide mineral fiberglass insulation to meet ASHRAE 90.1-1989 specifications in operating conditions with maximum Fluid Design Operating Temperature Range of 141-200°F and Mean Rating Temperature of 125°F.

PART 3 - EXECUTION

3.1 GENERAL

- .1 Install according to piping layout. Pipe drains and blow off connections to nearest drain.
- .2 Maintain proper clearance around equipment to permit performance of service maintenance. Check final location with the Consultant if different from that indicated on the Drawings prior to installation.
- .3 Should deviations beyond allowable clearances arise, request and follow the Consultant's instructions.
- .4 Refer to manufacturer's installation drawings.
- .5 Check that all openings for appurtenances and equipment operating weight conform to shop drawings.
- .6 If accessories and/or ancillaries are received knocked down, check assembly with the Consultant.

3.2 STRAINERS

- .1 Install in horizontal or down flow lines.
- .2 Ensure adequate clearance for removal of basket.
- .3 Install ahead of each pump (except vertical inline pumps), automatic control valve (larger than 3/4") and as indicated on the Drawings.

3.3 AIR VENTS

- .1 Install at high points of systems.
- .2 Pipe overflow to nearest drain.
- .3 On large-capacity air vent, install gate valve upstream of air vent.

END OF SECTION

PART 1 - GENERAL

2.1 WORK INCLUDED

- .1 Provide direct drive or belt drive horizontal fan coil units, where indicated on the Drawings, and of the types and performance as listed in the Schedules on the Drawings.
- .2 Fan coils to be complete with Minimum Efficiency Reporting Value ("MERV")13 filters, internal condensate drain, and overflow drain.

2.2 SUBMITTALS

- .1 Submit Shop Drawings for each fan coil unit in accordance with Section 23 05 10 and including the following data:
 - 1 Fan performance at the specified external static pressure at all three speeds.
 - 2 Heating and cooling coil performance at the specified entering air and water conditions at all three speeds.
 - 3 Sound power levels at all three speeds.
- .2 Provide data for inclusion in the Operating and Maintenance Manuals in accordance with Section 23 05 10.

2.3 MANUFACTURER CERTIFICATION

- .1 Provide manufacturer certification of the installation in accordance with Section 23 05 10.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Fan coil units shall be rated in accordance with the Air Conditioning and Refrigeration Institute ARI standards as a complete package.
- .2 Deliver units to the construction site completely assembled and in one piece. Protect casings from damage and cover all pipe and duct connections.
- .3 For direct drive units, provide unit mounted speed switch and electrical connection box, all factory wired with "OFF" position suitable for use as a disconnect switch.

2.2 CASING

- .1 Construct unit casing of 1.02 mm (20 gauge) galvanized steel, reinforced for rigidity.
- .2 Provide insulated return air plenum designed for rear air inlet including filter mounting.
- .3 Provide access to fans, motor and filter to permit removal with units installed.

- .4 Insulate entire casing, including return air plenum with minimum 12 mm (1/2") thick glass fibre insulation with neoprene coating.

2.3 DRAIN PAN

- .1 Provide insulated galvanized steel drain pan under the entire coil section and extending on the connection side sufficiently to permit control valves and return water piping to be mounted above.
- .2 Drain pan shall be double wall construction with insulation between inner and outer pans.
- .3 Provide copper drain connection at low end, and overflow drain.
- .4 Provide insulation on drain pan to comply with NFPA-90A.

2.4 FANS

- .1 Provide fans with forward curved, double width wheels, stable pressure curve and low sound power levels.

2.5 FILTER

- .1 Provide MERV13 filters mounted in return air plenum.
- .2 Filter sizes have been standardized for York Region stocking of replacement filters. Provide filter sizes as indicated in the HORIZONTAL FAN COIL UNIT SCHEDULE.

2.6 WATER COILS

- .1 Coils shall be aluminum fin mechanically bonded to copper tubing rated at 1725 kPa (250 psig) working pressure. Fit return connections with manual air vent.

2.7 MOTOR (DIRECT DRIVE UNITS)

- .1 Motors shall be Electronically Commutated Motor ("ECM") type with bronze sleeve type bearings and oil reservoirs directly connected to fan wheels. Motors shall have integral overload protection and the capability of starting at 78% of rated voltage and operating at 90% of rated voltage at a temperature of 10°C (50°F).

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install fan coil units in accordance with the manufacturer's installation instructions.
- .2 Support units from the slab with steel hanger rods and neoprene vibration isolators. Adjust mounts so that drain pan slopes to the condensate drain.
- .3 Insulate piping up tight to coils including control valves, and securely fasten insulation to casing.

- .4 Do not obstruct access to unit for service or filter replacement.
- .5 Direct power connection to fan coil units provided as part of the work of the electrical Subcontractor unless otherwise indicated.
- .6 Check all units for excessive vibration.
- .7 Provide isolation ball valves and unions on chilled and heating water supply and return piping. Mount control valves over drain pan.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide complete systems, including all necessary labour, services, products, materials and equipment as shown on the Drawings, listed in the Schedule below and as specified herein.
- .2 Provide and set all sleeves and anchors required to accommodate the work of Division 21, 22 and 23.
- .3 Read and be governed by the requirements of Section 23 05 48 - Vibration Isolation.

1.2 REFERENCE STANDARDS

- .1 Provide all work in accordance with the latest CSA and ASTM requirements and other applicable codes and the requirements of all local Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc.

PART 2 - PRODUCTS

2.1 PIPE AND EQUIPMENT SUPPORTS

- .1 Provide all necessary supports, hangers, racks, stands, pads and platforms required to adequately support the piping system and associated equipment from the structure.
- .2 Design bases and supports to carry loads safely under all conditions.
- .3 Provide all roof curbs and sleepers for roof mounted equipment. Curbs and sleepers shall be set in place prior to insulation of roof to allow for water proofing and flashing. Provide all necessary concrete or wood shims as required to ensure horizontal installation on sloping roof.
- .4 Provide all necessary inserts or beam clamps to connect hanger rods to the structure.
- .5 Refer to Schedule below for details of pipe hangers.
- .6 Provide angle iron wall brackets with specified hanger to support horizontal piping from wall.
- .7 For risers passing through floors, provide riser clamps (similar to Grinnell Fig. 261).

2.2 ANCHORS AND GUIDES

- .1 Provide anchors and guides of structural steel as required.
- .2 Provide Grinnell Fig. 257 pipe slide assemblies for horizontal pipes or Equivalent.
- .3 Provide Flexonics or Equivalent alignment guides for vertical pipes. For pipes 100 mm (4") and smaller, provide guides at every floor or 3 m (10 ft). For pipes larger than 100 mm (4"), provide guides at every second floor or 8 m (25 ft).

2.3 PIPE SLEEVES

- .1 Provide pipe sleeves for all penetrations through floors and walls. The work of this Division shall include setting of all required anchors and sleeves to accommodate the work of this Division.
- .2 Provide Schedule 40 steel pipe for exterior and interior walls above grade and extra heavy cast iron for exterior walls below grade and waterproofed walls.
- .3 Provide extra heavy cast iron or Drain Waste Vent (DWV) copper for waterproof floors. Provide a sleeve extension of 100 mm (4") above finished floor.

2.4 CEILING, WALL AND FLOOR PLATES

- .1 Provide, at floors and ceilings, for insulated and uninsulated pipe stamped steel, chrome plated split type, spring loaded with locking screws and concealed hinge.
- .2 Provide at walls for uninsulated pipe stamped steel, chrome plated split type, spring loaded with locking screws and concealed hinge. Provide at walls for insulated pipe flat seamed 1 mm (18 gauge) galvanized steel band fitted over insulation and 50 mm (2") outside pipe sleeve.

2.5 FLASHING AND COUNTER FLASHING

- .1 Provide flashing and counter flashing for all ducts, pipes, etc., passing through walls, waterproof floors and roofs.

2.6 PIPING EXPANSION

- .1 Provide and install piping with all necessary expansion loops, offsets, guides, joints, anchors, etc., as may be required.
- .2 Provide expansion joints in steel pipes 50 mm (2") and smaller Equivalent to Flexonics 2-ply stainless steel bellows, internal guides with male ends. Provide in steel pipes 65 mm (2-1/2") and larger 304 stainless steel bellows and all accessories.
- .3 Provide expansion joints in copper pipes, Flexonics or Equivalent 2-ply bronze bellows and all accessories.

2.7 PIPE HANGERS AND SPACING SCHEDULE

NOTES:

1. Hanger rods shall be cadmium plated continuous thread with locking nuts (Grinnell Fig. 146 or Equivalent).
2. Provide oversized hangers and galvanized steel insulation protection (Grinnell Fig. 167 or Equivalent) for insulated cold piping.
3. Provide insulation protection saddles (Grinnell Fig. 160 or Equivalent) under all insulated piping supported on roller or trapeze hangers.
4. Provide plastic coated hangers where hangers are in direct contact with copper pipes.

PIPE HANGERS AND SPACING SCHEDULE				
HANGER	PIPE SIZE	ROD DIAMETER	HANGER SPACING	
			Copper Pipe	Steel Pipe
Adjustable Ring Type (Grinnell Fig. 269 or)	12 mm and 20 mm ½" and ¾"	10 mm 3/8"	1.5 m 5'	1.5 m 5'
	25 mm 1"	10 mm 3/8"	1.8 m 6'	2.1 m 7'
Adjustable Clevis Type (Grinnell Fig. 260 or 65)	32 mm 1-1/4"	10 mm 3/8"	1.8 m 6'	2.1 m 7'
	40 mm and 50 mm 1-1/2" and 2"	10 mm 3/8"	2.4 m 8'	2.7 m 9'
	65 mm and 75 mm 2-1/2" and 3"	12 mm 1/2"	3.7 m 12'	4.3 m 14'
For uninsulated piping and insulated cold piping: Adjustable Clevis Type (Grinnell Fig. 260) For insulated hot piping: Roller Type (Grinnell Fig. 171)	100 mm and 125 mm 4" and 5"	5/8" 15 mm	N/A	5.2 m 17'
	150 mm 6"	19 mm 3/4"	N/A	5.2 m 17'
	200 mm and 250 mm 8" and 10"	22 mm 7/8"	N/A	5.8 m 19'
	300 mm 12"	22 mm 7/8"	N/A	7 m 23'

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Pipe and Equipment Supports

- .1 Provide housekeeping pads 100 mm (4") high from finished floor, extending 100 mm (4") beyond equipment and provide chamfered edges. Provide and install all required hold-down bolts.
- .2 Provide support of all suspended equipment from the bottom of the equipment.
- .3 All hanger rods shall be vertical, without bends or offsets.
- .4 Supply all necessary templates, anchor bolts, inserts and location drawings for the equipment supplied. Supervise the work of installation of the bases.

.2 Flashing and Counter Flashing

- .1 Flashing
 - .1 Provide flashings for mechanical penetration through roof.
- .2 Counter Flashing
 - .1 Provide flashings for mechanical penetration through roof.
- .3 Anchors and Guides
 - .1 Install guides adjacent to loops and expansion joints and adhere to manufacturer's recommendations.
 - .2 Install a minimum of two (2) guides on each side of loop or expansion joint.
- .4 Pipe Sleeves
 - .1 Provide and seal walls which separate areas of different air pressure with permanently resilient silicone base sealing compound.
 - .2 Install sleeves concentric with pipe and size sleeves to permit continuity and integrity of insulation through sleeves where required.
 - .3 Install watertight concrete curb 100 mm (4") high and extend 100 mm (4") beyond pipe at all sleeves extending through floor.
 - .4 Install sleeves 25 mm (1") beyond the exterior face of wall.
 - .5 Provide packing of loose fibreglass insulation for all sleeves between pipe and sleeve or insulation and sleeve, and seal both sides.
 - .6 Provide and seal sleeves with silicone base fire stop system equal to the fire rating of the wall approved by local inspector enforcing the Ontario Building Code.
 - .7 Seal all vertical sleeves through roofs, mechanical rooms and floors with permanently resilient waterproof silicone base sealing compound.
- .5 Piping Expansion
 - .1 Install expansion loops, offsets, guides, joints, etc., so piping will not be overstressed during expansion and contraction.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide vibration isolation and accessories to achieve the following sound levels:
 - .1 Office Areas: Noise Criteria ("NC") 35.
- .2 Refer to Vibration Isolation Schedule below for specific requirements of mechanical equipment.
- .3 Provide spring hangers for piping as specified herein.

1.2 SHOP DRAWINGS

- .1 Submit Shop Drawings in accordance with Section 21 05 01.
- .2 Provide separate Shop Drawings for each isolated system complete with performance and Product data.

PART 2 - PRODUCTS

2.1 ELASTOMERIC PADS

- .1 Type P1 - neoprene waffle or ribbed; 9 mm (3/8") minimum thickness; 50 durometer; maximum loading 350 kPa (50 psi).
- .2 Type P2 - rubber waffle or ribbed; 9 mm (3/8") minimum thickness; 30 durometer natural rubber; maximum loading 415 kPa (60 psi).
- .3 Type P3 - neoprene-steel-neoprene; 9 mm (3/8") minimum thickness neoprene bonded to 1.71 mm (14 gauge) steel plate; 50 durometer neoprene, waffle or ribbed; holes sleeved with isolation washers; maximum loading 350 kPa (50 psi).
- .4 Type P4 - rubber-steel-rubber; 9 mm (3/8") minimum thickness rubber bonded to 1.71 mm (14 gauge) steel plate; 30 durometer natural rubber, waffle or ribbed; holes sleeved with isolation washers; maximum loading 415 kPa (60 psi).

2.2 ELASTOMERIC MOUNTS

- .1 Type M1 - colour coded; neoprene in shear; maximum durometer of 60; threaded insert and two bolt-down holes; ribbed top and bottom surfaces.

2.3 ISOLATOR SPRINGS

- .1 Design stable springs so that ratio of lateral to axial stiffness is equal to or greater than 1.2 times the ratio of static deflection to working height. Select for 50% travel beyond rated load. Units shall be complete with levelling devices.
- .2 Ratio of height when loaded to diameter of spring shall be between 0.8 and 1.0.
- .3 Cadmium plated for all installations.
- .4 Colour code springs.

2.4 SPRING MOUNT

- .1 Zinc or cadmium plated hardware; housings coated with rust resistant paint.
- .2 Type M2 - stable open spring; support on bonded 6 mm (1/4") minimum thick ribbed neoprene or rubber friction and acoustic pad.
- .3 Type M3 - stable open spring; 6 mm (1/4") minimum thick ribbed neoprene or rubber friction and acoustic pad, bonded under isolator and on isolator top plate; levelling bolt for rigidly mounting to equipment.
- .4 Type M4 - restrained stable open spring: supported on bonded 6 mm (1/4") minimum thick ribbed neoprene or rubber friction and acoustic pad; built-in resilient limit stops, removable spacer plates.
- .5 Type M5 - enclosed spring mounts with snubbers for isolation up to 950 kg (430 lbs) maximum.
- .6 Performance as indicated on the Equipment Schedules provided on the Drawings.

2.5 HANGERS

- .1 Colour coded springs, rust resistant, painted box type hangers. Arrange to permit hanger box or rod to move through a 30 degree arc without metal to metal contact.
- .2 Type H1 - neoprene - in-shear, molded with rod isolation bushing which passes through hanger box.
- .3 Type H2 - stable spring, elastomeric washer, cup with molded isolation bushing which passes through hanger box.
- .4 Type H3 - stable spring, elastomeric element, cup with molded isolation bushing which passes through hanger box.
- .5 Type H4 - stable spring, elastomeric element with precompression washer and nut with deflection indicator.
- .6 Performance as indicated.

2.6 ACOUSTIC BARRIERS FOR ANCHORS AND GUIDES

- .1 Acoustic barriers: between pipe and support, consisting of 25 mm (1") minimum thickness heavy duty duck and neoprene isolation material.

2.7 HORIZONTAL THRUST RESTRAINT

- .1 Spring and elastomeric element housed in box frame; assembly complete with rods and angle brackets for equipment and ductwork attachment; provision for adjustment to limit maximum start and stop movement to 9 mm (3/8").
- .2 Arrange restraints symmetrically on either side of unit and attach at centre line of thrust.

2.8 VIBRATION ISOLATION SCHEDULE

VIBRATION ISOLATION SCHEDULE					
EQUIPMENT	BASE		ISOLATOR		REMARKS
	TYPE	THICKNESS mm (in)	TYPE	THICKNESS mm (in)	
Cabinet Fans	N/A	N/A	H2	25.4 (1)	
Vertical In-Line Pumps	N/A	N/A	P3	3.8 (0.15)	
Boilers	N/A	N/A	P3	3.8 (0.15)	

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install vibration isolation equipment in accordance with manufacturer's instructions and adjust mountings to level equipment.
- .2 Ensure piping, ducting and electrical connections to isolated equipment do not reduce system flexibility and that piping and ducting passage through walls and floors does not transmit vibrations.
- .3 Unless indicated otherwise in the Contract Documents, support piping connected to isolated equipment with spring mounts or spring hangers with 25 mm (1") minimum static deflection as follows:
 - .1 Up to Nominal Pipe Size ("NPS") 4: first 3 points of support.
 - .2 NPS 5 to NPS 8: first 4 points of support.
 - .3 NPS 10 and over: first 6 points of support.
 - .4 First point of support shall have a static deflection of twice deflection of isolated equipment, but not more than 50 mm (2").
- .4 Where isolation is bolted to floor, avoid short circuiting of sound pads by using vibration isolation rubber washers.

Block and shim level all bases so that ductwork and piping connections can be made to a rigid system at the operating level, before isolator adjustment is made. Ensure that there is no physical contact between isolated equipment and building structure.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide a complete system of identification.

1.2 EQUIPMENT

.1 Manufacturer's Nameplates

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

.2 System Nameplates

- .1 Provide laminated plastic plates with black face and white centre of minimum size 90 X 40 X 2.5 mm (3-1/2" X 1-1/2" X 1/8") nominal thickness, engraved with 6 mm (1/4") high lettering. Use 25 mm (1") lettering for major equipment.
- .2 Fasten nameplates securely in conspicuous place. Where nameplates cannot be mounted on cool surface, provide standoffs.
- .3 Identify equipment designation and number.
- .4 Submit list of nameplates to the Consultant for review prior to engraving.

1.3 PIPING

- .1 Identify medium in piping with markers showing name and service, including temperature, pressure and directional flow arrows in accordance with CGSB 24-GP-3a.
- .2 Conform to CGSB 1-GP-12c. Colour Coding System Schedule for new buildings.
- .3 Primary colour paint to conform to CGSB 1-GP-60M.
- .4 Manufactured pipe markers and colour bands:
 - .1 Plastic coated cloth material with protective overcoating and waterproof contact adhesive undercoating, suitable for continuous operating temperature of 150 degrees C (302 degrees F) and intermittent temperature of 200 degrees C (392 degrees F). Apply to prepared surfaces.
 - .2 50 mm (2") wide tape single wrap around pipe or pipe covering with ends overlapping one pipe diameter but not less than 25 mm (1") for colour bands.

- .3 Block capital letters 50 mm (2") high for pipes of 75 mm (3") nominal and larger outside diameter (including insulation) and not less than 20 mm (3/4") high for smaller diameters.
 - .4 Direction arrows 150 mm (6") long by 50 mm (2") wide for piping of 75 mm (3") nominal or larger outside diameter including insulation, and 100 mm (4") long by 20 mm (3/4") wide for smaller diameters. Use double headed arrows where direction of flow is reversible.
 - .5 Waterproof and heat resistant plastic marker tags for pipes and tubing 20 mm (3/4") nominal and smaller.
 - .6 Black pipe marker letters and direction arrows, white on red background for fire protection markers.
- .5 Identify piping with full description of medium using only abbreviations indicated in the Legend on the Drawings.
- .6 Location
- .1 Locate markers and classifying colours on piping systems so they can be seen from floor or platform.
 - .2 On each piping run at least once in each room.
 - .3 Maximum 15 m (50') between identifications in open areas.
 - .4 Both sides where piping passes through walls, partitions and floors.
 - .5 At point of entry and leaving, where piping is concealed in pipe chase or other confined space, and at each access opening.
 - .6 At start and end points of runs and at each piece of equipment.
 - .7 At major manual and automatic valves immediately upstream of valves.
 - .8 Identify branch, equipment or building served after valve.

1.4 DUCTWORK

- .1 Use 50 mm (2") high black stencilled letters (eg. "Supply Air", "Return Air", "Sanitary Exhaust", "General Exhaust") with directional flow arrow.
- .2 Maintain maximum 15 m (50') distance between markings.
- .3 Identify ducts on each side of dividing walls or partitions and beside each access door.
- .4 Stencil over final finish only.

1.5 VALVES AND CONTROLLERS

- .1 Provide brass tags with 12 mm (1/2") stamped code lettering and numbers filled with black paint, secured with non-ferrous chains or "S" hooks for valves and operating controllers except at plumbing fixtures and radiation and except in plain sight of equipment they serve.
- .2 Provide the Consultant with six identification flow diagrams of approved size for each system. Include

tag schedule, designating number, service, function, and location of each tagged item and normal operating position of valves.

- .3 Install where directed by the Consultant one copy of flow diagram and valve schedule mounted in glazed frame. Provide one copy in each operating and maintenance manual.
- .4 Consecutively number valves in systems.

1.6 FAN COIL UNITS

- .1 Provide label of t-bar at locations of ceiling mounted fan coil units to indicate fan coil location for filter and valve maintenance.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide testing, adjusting, balancing (TAB) and commissioning of all systems. Commissioning shall include putting into service, adjusting, calibrating and verifying all systems.
- .2 Provide the services of an independent balancing company, acceptable to the Consultant, to test, balance and adjust the air and water systems.
- .3 Comply with all applicable ASHRAE HVAC Systems and Applications, Testing, Adjusting and Balancing and Associated Air Balance Council (AABC) Standards.
- .4 Provide one (1) copy of the balancing report to the Consultant for review. Rebalance any systems which are not operating as intended following remedial work directed by the Consultant. Include all revisions in the final balancing report. Submit three (3) copies of the final report to the Consultant.
- .5 Provide one (1) copy of the balancing report to the Commissioning Agent for review. Rebalance any systems which are not operating as intended following remedial work directed by the Commissioning Agent. Include all revisions in the final balancing report. Submit one (1) copy of the final report to the Commissioning Agent.
- .6 Notify Commissioning Agent 14 Working Days prior to start of TAB to allow for Commissioning Agent to witness TAB procedures and testing.
- .7 Prior to commencing the work, identify all deficiencies in the mechanical systems which will affect the performance or accuracy of the work. Balance systems as they are available to meet the schedule for project completion.

PART 3 - EXECUTION

2.1 FLUID SYSTEMS

- .1 Test all fluid systems as follows:
 - 1 Plumbing systems to the Ontario Building Code ("OBC") requirements.
 - 2 Fire protection systems to OBC requirements.
 - 3 All systems not covered by OBC to 150% of working pressure, but not less than 1035 kPa (150 psig) or the maximum working pressure of expansion joints or isolators, for 24 hours.
- .2 Provide balancing and adjusting of all hydronic systems to achieve specified flow rates to within 5% of design flow rates.
- .3 Provide data in the balancing report which indicates flow rates, motor data, operating curves, operating temperatures and operating pressures for all pumps, coils and heat exchangers.
- .4 Mark balancing valves indicating the balanced position.
- .5 Verify operation of all control valves including perimeter heating.

2.2 AIR SYSTEMS

- .1 Provide balancing and adjusting of all air systems to achieve specified design values ($\pm 5\%$).
- .2 Provide data in the balancing report which indicates air volumes at each outlet, static pressures, fan data, motor data and coil data.
- .3 Provide duct traverse readings for each air handling unit and fan (with ducted connections and exceeding 1000 cfm).
- .4 Identify pressure drop across filters for all air handling units.
- .5 Adjust the air pattern for all diffusers as indicated on the Drawings or as directed by the Consultant.
- .6 Verify the operation of all control devices.

2.3 EQUIPMENT

- .1 Provide balancing, testing and adjusting of all equipment.
- .2 Include the following data in the balancing report:
 - 1 Electrical characteristics.
 - 2 Flow rates (air).
 - 3 Operating pressures and pressure drops.
 - 4 Operating efficiencies.

2.4 REPORTS

- .1 Submit all reports and forms to the Consultant for approval prior to any testing, balancing and adjusting. The forms shall be modified if they are not acceptable to the Consultant.
- .2 Submit all reports and forms to the Commissioning Agent for approval prior to any testing, balancing and adjusting. The forms shall be modified if they are not acceptable to the Commissioning Agent.
- .3 Provide all data required for evaluation of the work of this Section.
- .4 Provide schematic drawings of each system indicating points at which readings have been obtained.

2.5 DEMONSTRATION

- .1 Provide the demonstration of all systems and equipment, including complete documentation of the operating procedures of each system or piece of equipment. The time allotted for demonstration shall be adequate for the complexity of the systems and shall be acceptable to the Consultant.

2.6 TRIAL USAGE

- .1 Provide operation of all systems for purposes of demonstration and training of operating personnel.
Trial usage does not constitute acceptance by the Owner.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all thermal insulation and accessories for ducting of the types and thicknesses indicated in the Insulation Schedule contained in Section 23 07 15.
- .2 All rigid supply air ductwork from fan coil units shall be insulated.

1.2 REFERENCE STANDARDS

- .1 Meet the requirements of NFPA 90A. Maximum flame spread rating of 25 and maximum smoke developed rating of 50 in accordance with NFPA 255 and CAN4-S102 for all components of insulation system. Materials shall be tested in accordance with ASTM C411-82.

1.3 SAMPLES SUBMITTALS

- .1 Submit for the Consultant's approval, a complete assembly of each type of insulation system, insulation, coating and adhesive proposed. Mount samples on 12 mm (1/2") plywood board. Label each sample indicating type.

1.4 DEFINITIONS

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

PART 2 - PRODUCTS

2.1 D-1 MINERAL FIBRE BLANKET 20 degrees C TO 65 degrees C (68 degrees F TO 150 degrees F)

- .1 Material:
 - .1 CGSB 51-GP-11M mineral fibre blanket.

2.2 D-2 MINERAL FIBRE BLANKET WITH VAPOUR BARRIER -40 degrees C TO 65 degrees C (-40 degrees F TO 150 degrees F)

- .1 Material:
 - .1 CGSB 51-GP-11M mineral fibre blanket: CGSB 51-GP-52M for vapour barrier.

2.3 D-3 MINERAL FIBRE RIGID 20 degrees C TO 65 degrees C (68 degrees F TO 150 degrees F)

- .1 Material:
 - .1 CGSB 51-GP-10M, rigid mineral fibre board.

2.4 D-4 MINERAL FIBRE RIGID WITH VAPOUR BARRIER TO 65 degrees C (150 degrees F)

- .1 Material:
 - .1 CGSB 51-GP-10M, rigid mineral fibre board: CGSB 51-GP-52M vapour barrier jacket and facing material.

2.5 FASTENINGS

- .1 Tape: self-adhesive, 100 mm (4") wide.
- .2 Contact adhesive: quick-setting.
- .3 Lap seal adhesive: quick-setting for joints and lap sealing of vapour barriers.
- .4 For canvas:
 - .1 Washable adhesive for cementing canvas lagging cloth to duct insulation.
- .5 Pins:
 - .1 Weld pins 4 mm (1/8") in diameter, with 35 mm (1.5") diameter head for installation through the insulation. Length to suit thickness of insulation.
 - .2 Weld pins 2 mm (1/16") in diameter, for installation prior to applying insulation. Length to suit thickness of insulation. Nylon retain clips 32 mm (1.5") square.

2.6 JACKETS

- .1 Canvas:
 - .1 Apply in exposed areas: ULC listed plain weave, cotton fabric at 220 g/sq. m (6.5 oz./sq. yd).

PART 3 - EXECUTION

3.1 APPLICATION

- .1 Apply insulation after required tests have been completed and approved by the Consultant. Insulation and surfaces shall be clean and dry when installed and during application of any finish. Apply insulation materials, accessories and finishes to manufacturer's recommendations and as specified in the Contract Documents.
- .2 Vapour barriers and insulation to be unbroken over full length of duct or surface, without penetration for hangers, standing duct seams and without interruption at sleeves.

- .3 Use stand-offs for all duct-mounted control accessories.
- .4 Apply 1.0 mm (18 gauge) thick galvanized sheet metal corners to all ductwork in mechanical rooms.

3.2 INSTALLATION

- .1 General
 - .1 Adhere and seal vapour barrier using vapour seal adhesives.
 - .2 Stagger longitudinal and horizontal joints on multi-layered insulation.
- .2 Mechanical Fastenings
 - .1 On rectangular ducts, use 50% coverage of insulating cement and weld pins at not more than 200 mm (8") centres, but not less than two (2) rows per side and bottom.
- .3 Apply canvas jacket in all exposed areas.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- 1 Provide all thermal insulation and accessories for ducting, piping, and equipment of the types and thicknesses indicated in the following Insulation Schedule.
- .2 Refer to Specification Sections 23 07 13, 23 07 20, 23 05 14, and 23 05 15 for additional details.
- .3 Increase thickness of piping insulation to 50 mm (2") where piping over 50 mm (2") is electrically traced.

INSULATION SCHEDULE			
ITEM	TYPE	THICKNESS mm (in)	COMMENTS
Domestic Cold Water	P-2	25 (1)	
Domestic Hot Water Supply and Recirculating (2"Ø and Below)	P-1	25 (1)	
Domestic Hot Water Supply and Recirculating (Above 2"Ø)	P-1	40 (1-1/2)	
Chilled Water Supply and Return	P-2	40 (1-1/2)	
Heating Water Supply and Return	P-1	40 (1-1/2)	
Condensate Drains from Cooling Coils	P-2	25 (1)	
Supply Air Duct - Round	D-2	25 (1)	All rigid supply air ductwork within concealed ceiling spaces and shafts
Supply Air Duct - Rectangular	D-2	25 (1)	All rigid supply air ductwork within concealed ceiling spaces and shafts

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all thermal insulation and accessories for piping.
- .2 Refer to the Insulation Schedule (Section 23 07 15) for piping to be insulated, insulation type and thickness.
- .3 Insulate all associated fittings and valves.

1.2 REFERENCE STANDARDS

- .1 Meet the requirements of NFPA 90A-1985. Maximum flame spread rating of 25 and maximum smoke developed rating of 50 in accordance with NFPA 255 and CAN4-S102 for all components of insulation system. Materials tested in accordance with ASTM C411.

1.3 SAMPLES

- .1 Submit for the Consultant's approval a complete assembly of each type of insulation system, insulation coating and adhesive proposed. Mount samples on minimum 12 mm (1/2") plywood board. Label each sample indicating type.

1.4 DEFINITIONS

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

PART 2 - PRODUCTS

2.1 P-1 FORMED MINERAL FIBRE TO 200 degrees C (392 degrees F)

- .1 Material:
 - .1 CGSB 51-GP-9M, rigid mineral fibre sleeving for piping.

2.2 P-2 FORMED MINERAL FIBRE WITH VAPOUR BARRIER TO 85 degrees C (185 degrees F)

- .1 Material:
 - .1 CGSB 51-GP-9M, rigid mineral fibre sleeving for piping and CGSB 51-GP-52M, vapour barrier jacket and facing material.

- 2.3 P-3 FLEXIBLE MINERAL FIBRE WITH VAPOUR BARRIER TO 85 degrees C (185 degrees F)
 - .1 Material:
 - .1 CGSB 51-GP-11M, mineral fibre blanket for piping and CGSB 51-GP-52M vapour barrier jacket and facing material.

- 2.4 P-4 FLEXIBLE ELASTOMERIC -40 degrees C TO 100 degrees C (-40 degrees F TO 212 degrees F)
 - .1 Material:
 - .1 CAN2-51.40-M80 Aug-83, flexible elastomeric unicellular sheet and pipe covering.

- 2.5 FIRE RATED THERMAL PIPE INSULATION
 - .1 Equivalent to "Instant Firestop Inc." type "PI".
 - .2 ULC listed as a component of a fire stop system complete with vapour barrier jacket.

- 2.6 FASTENINGS
 - .1 For insulation systems P-1, P-2, P-3:
 - .1 Tape: self-adhesive.
 - .2 Lap seal adhesive: quick-setting for joints and lap sealing of vapour barriers.
 - .2 For insulation system P-4 and underside of roof drain body:
 - .1 Contact adhesive: quick-setting for seams and joints.
 - .2 Tape: self-adhesive Polyvinyl Chloride (PVC).
 - .3 For canvas:
 - .1 Washable adhesive for cementing canvas lagging cloth to piping insulation.

- 2.7 INSULATION CEMENT
 - .1 To CGSB 51-GP-6M.

- 2.8 JACKETS
 - .1 PVC
 - .1 Apply in accordance with CGSB 51-GP-53M only when specified.
 - .1 0.38 mm (28 gauge) thick minimum.
 - .2 Fitting covers, one piece premoulded to match.
 - .3 Fastenings standard to manufacturer.

PART 3 - EXECUTION

3.1 APPLICATION

- .1 Apply insulation after required tests have been completed and approved by the Consultant. Insulation and surfaces shall be clean and dry when installed and during application of any finish. Apply insulation materials, accessories and finishes in accordance with manufacturer's recommendations and as specified in the Contract Documents.
- .2 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.
- .3 On piping with insulation and vapour barrier that passes through a fire separation (wall, floor slab, etc.), provide fire rated thermal insulation to maintain continuity of vapour barrier and insulation without violating the integrity of the fire separation. Fire rated insulation shall be installed as part of a ULC listed fire stop system to provide the same rating as the fire separation.
- .4 Apply PVC jacket to all exposed piping insulation located indoors unless otherwise indicated in the Contract Documents. PVC jacket is not required for chrome plated sections of water and drain piping, only for non-chrome plated piping sections.

3.2 INSTALLATION

- .1 Preformed: sectional up to NPS 12, sectional or curved segmented greater than NPS 12.
- .2 Multi-layered: staggered butt joint construction.
- .3 Vertical pipe greater than NPS 3: insulation supports welded or bolted to pipe directly above lowest pipe fitting. Thereafter, locate on 4.5 m (15') centres.
- .4 Expansion joints: terminate single layer and each layer of multiple layers in straight cut. Leave space of 25 mm (1") between terminations. Pack void tightly with mineral fibre. Protect joints with stainless steel or aluminum sleeves.
- .5 Terminate insulation with insulation cement.
- .6 Bevel away for studs and nuts to permit their removal without damage to insulation, and seal with insulating cement.
- .7 Insulation is not required for chrome plated piping, valves and fittings.
- .8 Provide removable sections of insulation for fittings or devices requiring routine maintenance such as strainers.

3.3 FASTENINGS

- .1 Secure pipe insulation by tape at each end and centre of section, but not greater than 900 mm (36") on centres.

END OF SECTION

PART 1 – GENERAL

1.1 General

- .1 The purpose of this section is to specify responsibilities in the commissioning process for the work of Division 23.
- .2 The systems to be commissioned are listed in Section 01 91 00, subsection.1.9. The abbreviations and definitions used in Section 01 91 00 apply to this Section 23 08 00 – HVAC System Commissioning.
- .3 Commissioning shall take into account the requirements under Division 23 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. For the purposes of completing work under Division 23, the Contractor shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 Responsibilities

- .1 Mechanical Subcontractor. The responsibilities of the Contractor and its HVAC Subcontractor, during construction and acceptance phases in addition to those listed above are (all references apply to commissioned equipment only):
 - .1 Documentation of all procedures performed shall be provided and forwarded to the Consultant. Written documentation must contain recorded test values of all mechanical tests performed per the individual product specification.
 - .2 The start-up service company shall be present during energization of the mechanical equipment. Jobsite and equipment access must be provided by the Mechanical Subcontractor.
 - .3 Supply a power source, specified by the start-up service company, for on-site test equipment.
 - .4 Attend all factory witness testing required within the respective specification sections. The Contractor shall include all related costs in the total Contract Price submitted with its bid.
 - .5 Perform tests using qualified personnel. Provide necessary instruments and equipment.
 - .6 The Contractor shall include the cost of commissioning in the total Contract Price, submitted with its bid..
 - .7 The Contractor shall ensure it complies with the requirements of GC -10 Subcontractors and ensures that the Mechanical Subcontractor complies with the Contract requirements for submittal data, O&M data and training.
 - .8 Attend a commissioning scoping meeting and other necessary meetings scheduled by the CA to facilitate the Cx process.
 - .9 Provide normal cut sheets and shop drawing submittals to the CA of commissioned equipment. Provide additional requested documentation, prior to normal O&M manual submittals, to the CA for development of pre-functional and functional testing procedures.
 - .1 Include detailed manufacturer installation and start-up, operating, troubleshooting and maintenance procedures, full details of any owner-contracted tests, fan curves, full factory testing reports, and full warranty information, including all responsibilities of the Owner to keep the warranty in force clearly identified. In addition, the installation and checkout materials that are actually shipped inside the equipment and the actual field checkout sheet forms to be used by the factory or field technicians shall be submitted to the Commissioning Agent.

- .2 The Commissioning Agent may request further documentation necessary for the commissioning process. This data request may be made prior to normal submittals.
- .10 Provide a copy of the O&M manuals submittals of commissioned equipment, through normal channels, to the CA for review.
- .11 Assist (along with the design engineers) in clarifying the operation and control of commissioned equipment in areas where the specifications, control drawings or equipment documentation is not sufficient for writing detailed testing procedures.
- .12 Provide assistance to the CA in preparation of the specific functional performance test procedures specified in Division 23. Subs shall review test procedures to ensure feasibility, safety and equipment protection and provide necessary written alarm limits to be used during the tests.
- .13 Develop a full start-up and checkout plan using manufacturer's start-up procedures and the pre-functional test sheets from the CA. Submit manufacturer's detailed start-up procedures and the full start-up plan and procedures and other requested equipment documentation to CA for review.
- .14 During the start-up and checkout process, execute and document the mechanical-related portions of the pre-functional test sheets provided by the CA for all commissioned equipment.
- .15 Perform and clearly document all completed start-up and system operational checkout procedures, providing a copy to the CA.
- .16 Provide skilled technicians to execute starting of equipment and to execute the functional performance tests. Ensure that they are available and present during the agreed upon schedules and for sufficient duration to complete the necessary tests, adjustments and problem-solving.
- .17 Perform functional performance testing under the direction of the CA for specified equipment in Section 01 91 00, subsection 1.9. Assist the CA in interpreting the monitoring data, as necessary.
- .18 Correct deficiencies (differences between specified and observed performance) as interpreted by the CA, PM and A/E and retest the equipment.
- .19 Prepare O&M manuals according to the Contract Documents, including clarifying and updating the original sequences of operation to as-built conditions.
- .20 During construction, maintain as-built red-line drawings for all drawings and final CAD as-builts for contractor-generated coordination drawings. Update after completion of commissioning (excluding deferred testing). Prepare red-line as-built drawings for all drawings and final as-builts for contractor-generated coordination drawings.
- .21 Provide training of the Owner's operating personnel as specified in the Contract Documents.
- .22 Coordinate with equipment manufacturers to determine specific requirements to maintain the validity of the warranty.
- .23 Execute seasonal or deferred functional performance testing, witnessed by the CA, according to the specifications.
- .24 Correct deficiencies and make necessary adjustments to O&M manuals and as-built drawings for applicable issues identified in any seasonal testing.
- .25 Assist and cooperate with the TAB Subcontractor and CA by:
 - .1 Putting all HVAC equipment and systems into operation and continuing the operation during each working day of TAB and commissioning, as required.
 - .2 Including cost of sheaves and belts that may be required by TAB.

- .3 Providing test holes in ducts and plenums where directed by TAB to allow air measurements and air balancing. Providing an approved plug.
- .4 Providing temperature and pressure taps according to the Construction Documents for TAB and commissioning testing.
- .26 Install a Pressure Transducer (P/T) plug at each water sensor which is an input point to the control system.
- .27 List and clearly identify on the as-built drawings the locations of all air-flow stations.
- .28 Prepare a preliminary schedule for pipe to be installed under Division 23 and duct system testing, flushing and cleaning, equipment start-up and TAB start and completion for use by the CA. Update the schedule as appropriate.
- .29 Notify the PM/GC or CA depending on protocol, when pipe and duct system testing, flushing, cleaning, start-up of each piece of equipment and TAB will occur. Be responsible to notify the PM/GC or CA, ahead of time, when commissioning activities not yet performed or not yet scheduled will delay construction. Be proactive in seeing that commissioning processes are executed, and that the CA has the scheduling information needed to efficiently execute the commissioning process.
- .2 TAB Subcontractor: The duties of the TAB Subcontractor, in addition to those listed in 1.2.1 are:
 - .1 Six weeks prior to starting TAB, submit to the PM/GC the qualifications of the site technician for the project, including the name of the contractors and facility managers of recent projects the technician on which was lead. The Owner will approve the site technician's qualifications for this project.
 - .2 Submit the outline of the TAB plan and approach for each system and component to the CA, PM/GC and the Controls Subcontractor six weeks prior to starting the TAB. This plan will be developed after the TAB has some familiarity with the control system. The submitted plan will include:
 - .1 Certification that the TAB Subcontractor has reviewed the construction documents and the systems with the design engineers and contractors to sufficiently understand the design intent for each system.
 - .2 An explanation of the intended use of the building control system. The Controls Subcontractor will comment on feasibility of the plan.
 - .3 All field checkout sheets and logs to be used that list each piece of equipment to be tested, adjusted and balanced with the data cells to be gathered for each.
 - .4 Discussion of what notations and markings will be made on the duct and piping drawings during the process.
 - .5 Final test report forms to be used.
 - .6 Detailed step-by-step procedures for TAB work for each system and issue: terminal flow calibration (for each terminal type), diffuser proportioning, branch / submain proportioning, total flow calculations, rechecking, diversity issues, expected problems and solutions, etc. Criteria for using air flow strengtheners or relocating flow stations and sensors will be discussed. Provide the analogous explanations for the water side.
 - .7 List of all air flow, water flow, sound level, system capacity and efficiency measurements to be performed and a description of specific test procedures, parameters, formulas to be used.
 - .8 Details of how total flow will be determined (Air: sum of terminal flows via BAS calibrated readings or via hood readings of all terminals, supply (SA) and return air (RA) pilot traverse, SA or RA flow stations. Water: pump curves, circuit setter, flow station, ultrasonic, etc.).

- .9 The identification and types of measurement instruments to be used and their most recent calibration date.
- .10 Specific procedures that will ensure that both air and water side are operating at the lowest possible pressures and provide methods to verify this.
- .11 Confirmation that TAB understands the outside air ventilation criteria under all conditions.
- .12 Details of whether and how minimum outside air cfm will be verified and set and for what level (total building, zone, etc.).
- .13 Details of how building static and exhaust fan / relief damper capacity will be checked.
- .14 Proposed selection points for sound measurements and sound measurement methods.
- .15 Details of methods for making any specified coil or other system plant capacity measurements.
- .16 Details of any TAB work to be done in phases (by floor, etc.), or of areas to be built out later.
- .17 Details regarding specified deferred or seasonal TAB work.
- .18 Details of any specified false loading of systems to complete TAB work.
- .19 Details of all exhaust fan balancing and capacity verifications, including any required room pressure differentials.
- .20 Details of any required interstitial cavity differential pressure measurements and calculations.
- .21 Plan for hand-written field technician logs of discrepancies, deficient or uncompleted work by others, contract interpretation requests and lists of completed tests (scope and frequency).
- .22 Plan for formal progress reports (scope and frequency).
- .23 Plan for formal deficiency reports (scope, frequency and distribution).
- .3 A running log of events and issues shall be kept by the TAB field technicians. Submit hand-written reports of discrepancies, deficient or uncompleted work by others under this Contract, contract interpretation requests and lists of completed tests to the CA and PM/GC at least twice a week.
- .4 Communicate in writing to the Controls Subcontractor all setpoint and parameter changes made, or problems and discrepancies identified during TAB which affect the control system setup and operation.
- .5 Provide a draft TAB report within 10 Working Days of completion of commissioning. A copy will be provided to the CA. The report will contain a full explanation of the methodology, assumptions and the results in a clear format with designations of all uncommon abbreviations and column headings. The report should follow the latest and most rigorous reporting recommendations by AABC, NEBB.
- .6 Provide the CA with any requested data, gathered, but not shown on the draft reports.
- .7 Provide a final TAB report for the CA with details, as in the draft.
- .8 Conduct functional performance tests and checks on the original TAB as specified for TAB in Section 23 05 93.

PART 2- PRODUCTS

- .1 NOT USED

PART 3- EXECUTION

3.1 Submittals

- .1 Provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 23 requirements.

3.2 Start-up of Equipment

- .1 Follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in 01 91 00. Ensure the start-up responsibility under Division 23 is met and complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the commissioning agent or Owner.
- .2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment under Division 23 the Contractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The supplier shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the Manufacturers Recommendations the equipment may be started.
- .6 All equipment shall be started by the manufacturer's representative.

3.3 Pre-Functional Test Sheets

- .1 Pre-functional test sheets contain items to be performed under Division 23. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.
- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, start-up and initial checkout. Items that do not apply should be noted along with the reasons on the checklist. If this checklist is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = Contractor including all Subcontractors, CA = Commissioning Agent, CC = Controls Subcontractor, EC = Electrical Subcontractor, PM/GC = General Contractor, MC = Mechanical Subcontractor, SC = Sheet Metal Subcontractor, TAB = Test and Balance Subcontractor.

3.4 Operations and Maintenance Manuals

- .1 Compile and prepare documentation for all equipment and systems covered in Division 23 and deliver to the GC for inclusion in the O&M manuals
- .2 The CA shall receive a copy of the O&M manuals for review.

3.5 Training of Owner Personnel

- .1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.
- .3 Mechanical Subcontractor. The mechanical contractor shall have the following training responsibilities:
 - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
 - .2 Provide designated Owner personnel with comprehensive orientation and training in the understanding of the systems and the operation and maintenance of each piece of HVAC equipment including, but not limited to, pumps, boilers, furnaces, chillers, heat rejection equipment, air conditioning units, air handling units, fans, terminal units, controls and water treatment systems, etc.
 - .3 Training shall normally start with classroom sessions followed by hands-on training on each piece of equipment, which shall illustrate the various modes of operation, including start-up, shutdown, fire/smoke alarm, power failure, etc.
 - .4 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 - .5 Ensure the appropriate trade or manufacturer's representative shall provide the instructions on each major piece of equipment. This person may be the start-up technician for the piece of equipment, the installing contractor or manufacturer's representative. Practical building operating expertise as well as in-depth knowledge of all modes of operation of the specific piece of equipment is required. More than one party may be required to execute the training.
 - .6 The controls contractor shall attend sessions other than the controls training, as requested, to discuss the interaction of the controls system as it relates to the equipment being discussed.
 - .7 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 - .8 Training shall include:
 - .1 Use of the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - .2 A review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - .3 Discussion of relevant health and safety issues and concerns.
 - .4 Discussion of warranties and guarantees.

- .5 Common troubleshooting problems and solutions.
- .6 Explanatory information included in the O&M manuals and the location of all plans and manuals in the facility.
- .7 Discussion of any peculiarities of equipment installation or operation.
- .9 The format and training agenda in The HVAC Commissioning Process, ASHRAE Guideline 0-2005 is recommended.
- .10 Classroom sessions shall include the use of overhead projections, slides, video/audio-taped material as might be appropriate.
- .11 Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and preventative maintenance for all pieces of equipment.
- .12 The mechanical contractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .13 Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

3.6 Deferred Testing

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

3.7 WRITTEN WORK PRODUCTS

- .1 Written work products under Division 23 shall consist of the start-up and initial checkout plan as described in Section 01 91 00, as well as completed start-up, initial checkout and pre-functional test sheets.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all low pressure ductwork and accessories as shown on the Drawings.

PART 2 - PRODUCTS

2.1 CLASSIFICATION

.1 Ductwork

Class	Maximum Pressure Pa ("Water Gauge)	Maximum Velocity Class m/s (fpm)	Seal
I	500 (2)	12.5 (2500)	A
II	250 (1)	12.5 (2500)	B
III	125 (0.5)	10.0 (2000)	C

.2 Seals

- 1 Class A: seams, joints and connections made airtight with sealing compound and tape.
- 2 Class B: seams, joints and connections made airtight with sealing compound.
- 3 Class C: transverse joints and connections made airtight with sealing compound. Longitudinal seams unsealed.

2.2 SEALANT AND TAPE

- .1 Sealant: oil resistant, polymer type flame resistant high velocity duct sealing compound. Temperature range of -30 degrees C to 93 degrees C (-22 degrees F to 200 degrees F).
- .2 Tape: polyvinyl treated, open weave glass fibre tape, 50 mm (2") wide.

2.3 DUCT LEAKAGE

- .1 Class I: 0.50% of total system design flow at 500 Pa (2" W.G.).
- .2 Class II: 1.00% of total system design flow at 250 Pa (1" W.G.).
- .3 Class III: 1.50% of total system design flow at 125 Pa (1/2" W.G.).
- .4 Class IV: 5.00% of total system design flow at 125 Pa (1/2" W.G.).

2.4 FITTINGS

- .1 Fabrication: to SMACNA standards
- .2 Radius elbows: standard radius or short radius with single thickness turning vanes.
- .3 Square elbows: to 400 mm (16") with single thickness vanes.
- .4 Square elbows: over 400 mm (16") with double thickness vanes.
- .5 Main supply duct branches with or without splitter damper. If splitter damper is not used, provide branch and main duct balancing dampers.
- .6 Sub-branch duct with 45 degree entry and balancing damper on branch, or sub-branch duct with square connection, volume extractor and branch duct balancing damper.
- .7 Transitions:
 - 1 Diverging: 20 degree maximum included angle.
 - 2 Converging: 30 degree maximum included angle.
- .8 Offsets: square elbows or radius elbows as indicated on the Drawings.
- .9 Obstruction deflectors: maintain full cross-sectional area. Maximum included angles for transitions.

2.5 GALVANIZED STEEL

- .1 Lock forming quality: to ASTM A525M-80, Z90 zinc coating.
- .2 Thickness: to ASHRAE and SMACNA.
- .3 Fabrication: to ASHRAE and SMACNA.
- .4 Joints: to ASHRAE and SMACNA or proprietary manufactured duct joint. Proprietary manufactured flanged duct joint shall be considered to be a Class A seal.
- .5 All round exposed ductwork shall be of spiral wound manufacture.

2.6 HANGERS AND SUPPORTS

- .1 Strap hangers: of same material as duct, but next sheet metal thickness heavier than duct.
- .2 Hanger configuration: to ASHRAE and SMACNA. Maximum size duct supported by strap hanger: 500 mm (20").
- .3 Hangers: galvanized steel angle with galvanized steel rods to ASHRAE and SMACNA, In accordance with the following table:

Duct Size

Angle Size

Rod Size

mm (")	mm (")	mm (")
up to 750 (30)	25 x 25 x 3 (1 x 1 x 1/8)	6 (1/4)
751 (30) to 1050 (42)	40 x 40 x 3 (1.5 x 1.5 x 1/8)	6 (1/4)
1051 (42) to 1500 (60)	40 x 40 x 3 (1.5 x 1.5 x 1/8)	10 (3/8)
1501 (60) to 2100 (84)	50 x 50 x 3 (2 x 2 x 1/8)	10 (3/8)
2101 (84) to 2400 (96)	50 x 50 x 5 (2 x 2 x 3/16)	10 (3/8)
2401 (96) and over	50 x 50 x 6 (2 x 2 x 1/4)	10 (3/8)

.4 Upper hanger attachments:

0.1 For concrete: manufactured concrete inserts.

PART 3 - EXECUTION

3.1 GENERAL

- .1 Install ducts in accordance with ASHRAE and SMACNA.
- .2 Provide all duct supports in accordance with SMACNA standards. Maximum duct sag shall be limited to ½ inch per foot.
- .3 All HVAC ductwork and equipment, including existing equipment, shall be protected from exposure to moisture and from collecting dust, debris, odours and other contaminants while demolition and construction activities are ongoing.
- .4 The ends of all ductwork and openings in HVAC equipment are to be sealed tightly, whether they are installed or being stored prior to installation. All ductwork and equipment that is waiting to be installed must be kept off the floor a minimum of 75 mm.
- .5 Provide adequate access into ductwork for cleaning purposes.
- .6 Immediately after installation, the open ends of return and exhaust ductwork shall be sealed with 6-mil plastic.
- .7 HVAC equipment and ductwork left in place during demolition and construction shall be wrapped in 6-mil plastic sheeting.
- .8 Do not break continuity of insulation vapour barrier with hangers or rods. Insulate strap hangers 100 mm (4") beyond insulated duct.
- .9 Support risers in accordance with ASHRAE and SMACNA, or as indicated on the Drawings.
- .4 Unless otherwise indicated on the Drawings, ductwork shall be constructed of galvanized steel.
- .5 All supply and exhaust ductwork shall be Seal Class C. All other ductwork shall be Class I, Class II or Class III as required.

3.2 HANGERS

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

Duct Size mm (")	Spacing mm (")
to 1500 (60)	3000 (10)
1501 (60) and over	2500 (8)

3.4 SEALING AND TAPING

- .1 Apply sealant to outside of joint in accordance with manufacturer's recommendations.
- .2 Bed tape in sealant and recoat with minimum of one (1) red coat of sealant in accordance with manufacturer's recommendations.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all duct accessories.

1.2 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 FLEXIBLE CONNECTIONS

- .1 Frame: galvanized sheet metal frame 1.5 mm (16 gauge) thick with fabric clenched by means of double locked seams.
- .2 Material: Fire resistant, self-extinguishing, neoprene coated glass fabric, temperature rated at -40°C to 90°C (-40°F to 194°F), density of 1.3 kg.sq. m (25 lbs/sq.ft).

2.2 SEALANT AND TAPE

- .1 Sealant: oil resistant, polymer type flame resistant high velocity duct sealing compound. Temperature range of -30°C to 93°C (-22°F to 200°F).
- .2 Tape: polyvinyl treated, open weave fibre glass tape, 50 mm (2") wide.

2.3 ACCESS DOORS

- .1 General
 - 1 Non-insulated sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm (24 gauge) thick, complete with sheet metal angle frame.
 - 2 Insulated sandwich construction of same material as duct, one sheet metal thickness heavier, minimum 0.6 mm (24 gauge) thick, complete with sheet metal angle frame and 25 mm (1") thick rigid glass fibre insulation.
- .2 Gaskets: neoprene or foam rubber.
- .3 Hardware:
 - 1 Up to 300 mm x 300 mm (12" x 12"): two (2) sash locks.
 - 2 301 mm to 450 mm (12" to 18"): four (4) sash locks.
 - 3 451 mm to 1000 mm (18" to 40"): piano hinge and minimum two (2) sash locks.

- 4 Doors greater than 1000 mm (40"): piano hinge and two (2) handles operable from both sides.

2.4 TURNING VANES

- .1 Factory or shop fabricated, single or double thickness in accordance with the recommendations of SMACNA.

2.5 INSTRUMENT TEST PORTS

- .1 1.6 mm (14 gauge) thick steel zinc plated after manufacture.
- .2 Cam lock handles with neoprene expansion plug and handle chain.
- .3 28 mm (1") minimum inside diameter. Length to suit insulation thickness.
- .4 Neoprene mounting gasket.

2.6 BACK DRAFT DAMPERS

- .1 Automatic gravity operated, multi leaf, aluminum construction with nylon bearings, and centre pivoted.

PART 3 - EXECUTION

3.1 INSTALLATION

.1 Flexible Connections

- 1 Install in following locations:
 - 1 Inlets to supply air units, except where units are internally isolated.
 - 2 Outlets from supply air units except where units are internally isolated.
 - 3 Inlets and outlets of fans.
 - 4 As indicated on the Drawings.
- 2 Length of connection: 150 mm (6").
- 3 Minimum distance between metal parts when system in operation: 75 mm (3").
- 4 Install in accordance with recommendations of SMACNA.

.2 Sealants and tapes

- 1 Apply sealant in accordance with recommendations of SMACNA and the manufacturer.
- 2 Bed tape in sealant and recoat with minimum of one coat of sealant in accordance with the manufacturer's recommendations.

.3 Access doors

1 Size:

- 1 760 mm x 1500 mm (30" x 60") for person size entry.
- 2 600 mm x 1200 mm (24" x 48") for servicing entry.
- 3 300 mm x 300 mm (12" x 12") for viewing.
- 4 As indicated on the Drawings.

2 Location

- 1 At fire and smoke dampers.
- 2 At control dampers.
- 3 At devices requiring maintenance.
- 4 At locations required by the Ontario Building Code.
- 5 As indicated on the Drawings.

.4 Instrument Test Ports

1 General

- 1 For traverse readings, install in accordance with recommendations of SMACNA.
- 2 For temperature readings, install in accordance with recommendations of SMACNA.
- 3 Install in accordance with manufacturer's instructions.

2 Locations

1 Traverse:

- 1 At ducted inlets to roof and wall exhausters.
- 2 At inlets and outlets of other fan systems.
- 3 At main and sub-main ducts.
- 4 As indicated or required for full, accurate readings.

2 Temperature:

- 1 At outside air intakes.
- 2 At mixed air locations.
- 3 At inlet and outlet of coils.

- 4 Downstream of junctions of two converging air streams of different temperatures.
 - 5 As indicated on the Drawings or required for all necessary readings.
- .5 Turning vanes
- 1 Install in accordance with recommendations of SMACNA.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all balancing dampers and accessories.

PART 2 - PRODUCTS

2.1 SPLITTER DAMPERS

- .1 Of same material as duct but one sheet metal thickness heavier, with appropriate stiffening.
- .2 Double thickness construction, airfoil blade profile.
- .3 Size and configuration to recommendations of SMACNA.
- .4 Control rod with locking device.
- .5 Bend end of rod to prevent end from entering duct.
- .6 Pivot: piano hinge.

2.2 SINGLE BLADE DAMPERS

- .1 Of same material as duct. V-groove stiffened.
- .2 Size and configuration to recommendations of SMACNA, except maximum height 250 mm (10").
- .3 Locking quadrant, with shaft extension to accommodate insulation thickness.
- .4 Inside and outside bronze end bearings.

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.
- .3 Maximum blade height: 100 mm (4").
- .4 Bearings: pin in bronze bushings.
- .5 Linkage: shaft extension with locking quadrant.
- .6 Channel frame material of same material as duct, complete with angle stop.

2.4 DIVERTING DAMPERS

- .1 Adjustable, curved vanes mounted in supporting frame.
- .2 All aluminum construction.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install where indicated on the Drawings and as required to completely balance the air systems.
- .2 Install in accordance with recommendations of SMACNA and in accordance with manufacturer's instructions.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all fire dampers and accessories.

1.2 SUBMITTALS

- .1 Submit Shop Drawings for each type of fire damper in accordance with Section 21 05 01.
- .2 Provide data for inclusion in the Operating and Maintenance Manuals in accordance with Section 21 05 01.

1.3 CERTIFICATION OF RATINGS

- .1 Catalogue or published ratings shall be those obtained from tests carried out by the manufacturer or those ordered by the manufacturer from an independent testing agency signifying adherence to applicable codes and standards.

PART 2 - PRODUCTS

2.1 FIRE DAMPERS

- .1 Fire dampers shall be listed and bear label of ULC and shall meet requirements of Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc.
- .2 Mild steel, factory fabricated for fire rating requirement to maintain integrity of fire wall and/or fire separation.
- .3 Top hinged: offset single damper, round or square; multi-blade hinged or interlocking type; roll door type; guillotine type; sized to maintain full duct cross section.
- .4 Fusible link actuated, weighted to close and lock in closed position when released or having negator-spring-closing operator for multi-leaf type or roll door type in horizontal position with vertical air flow.
- .5 Frame and 40 mm x 40 mm x 3 mm (1.5" x 1.5" x 1/8") angle iron on full perimeter of frame on both sides of fire wall and/or fire wall being pierced.
- .6 All fire dampers shall be type 'B' fire dampers to maintain full duct cross sectional area when open.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install fire dampers in accordance with NFPA 90A.
- .2 Maintain integrity of fire wall and/or fire separation.
- .3 After completion and prior to concealment, obtain approvals of complete installation from the Consultant and Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all flexible ductwork.

1.2 REFERENCE STANDARDS

- .1 Comply with the requirements of:
 - .1 ULC S110M for fire tests for air ducts.
 - .2 UL 181 for factory made air ducts and connectors.
 - .3 NFPA 90A for installation of air conditioning and ventilating systems.
 - .4 NFPA 90B for installation of warm air heating and air conditioning systems.
 - .5 SMACNA for flexible duct installation and duct support standards.

1.3 CERTIFICATION OF RATINGS

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

1.4 SAMPLES

- .1 Submit samples with Product data of each different type of flexible duct being used.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Factory fabricated.
- .2 Pressure drop coefficients listed below are based on sheet metal duct pressure drop coefficient of 1.00.
- .3 Flame spread rating not to exceed 25. Smoke developed rating not to exceed 50.

2.2 METALLIC - UNINSULATED

- .1 Spiral wound flexible aluminum.
- .2 Performance:

- .1 Minimum working pressure: 2.5 kPa (10" WG)
- .2 Maximum pressure drop coefficient : 3.

2.3 METALLIC - INSULATED

- .1 Spiral wound flexible aluminum with factory applied flexible glass fibre thermal insulation with vapour barrier and vinyl jacket.
- .2 Performance:
 - .1 Minimum working pressure: 2.5 kPa (10" WG).
 - .2 Maximum pressure drop coefficient : 3.
 - .3 Thermal loss/gain: 22 W/sq.m degree C (4 BTU/hr./sq.ft degree F).

2.4 METALLIC – ACOUSTIC FLEX

- .1 Spiral wound perforated flexible aluminum with factory applied flexible glass fibre insulation and flame retardant non-toxic polyethylene vapour barrier.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION

- .1 Provide acoustic metallic flexible duct in all areas unless otherwise indicated on the Drawings.
- .2 Provide minimum three (3) screws or stainless steel worm drive clamps to fasten flexible ducts to diffusers or rigid ductwork. Completely seal connections with tape.
- .3 Attach flexible ductwork to fan coil unit supply air ductwork with pressure clamps. Fastening with tie-wraps is not acceptable.
- .4 Support in accordance with SMACNA.
- .5 Maximum length of flexible duct: 1.9 m (6 ft).

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all acoustic duct lining and accessories.

1.2 REFERENCE STANDARDS

- .1 Carry out work in accordance with recommendations of ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers).

PART 2 - PRODUCTS

2.1 DUCT LINER

.1 General

- .1 Fibrous glass duct liner density 22 kg/cu. m (1.5 lb/cu.ft): one side coated with black neoprene.
- .2 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50.

.2 Rigid

- .1 25 mm (1") thick, to CGSB 51-GP-10M fibrous glass rigid board duct liner. For ductwork located outdoors, increase thickness to 50mm (2").
- .2 Use on all flat surfaces.

.3 Flexible

- .1 25 mm (1") thick, to CGSB 51-GP-11M+Amdt-Apr-78, fibrous glass blanket duct liner. For ductwork located outdoors, increase thickness to 50mm (2").
- .2 Use on round or oval surfaces.

2.2 ADHESIVE

- .1 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range – 30 degrees C to 93 degrees C (-22 degrees F to 200 degrees F). Meet requirements of NFPA 90A.

2.3 FASTENERS

- .1 Weld pins 2.0 mm (0.8") diameter, length to suit thickness of insulation. Metal retaining clips, 32 mm (1-1/4") square.

2.4 JOINT TAPE

- .1 Poly-vinyl treated open weave fibre glass membrane 50 mm (2") wide.

2.5 SEALER

- .1 Flame spread rating shall not exceed 25. Smoke development rating shall not exceed 50. Temperature range -68 degrees C to 93 degrees C (-90 degrees F to 200 degrees F). Meet requirements of NFPA 90A-1996.

PART 3 - EXECUTION

3.1 GENERAL

- .1 Line inside of ducts where indicated on the Drawings or in Schedules provided on the Drawings.
- .2 Duct dimensions shown on the Drawings are clear inside. Increase actual duct dimensions accordingly to maintain clear dimensions indicated on Drawings.
- .3 Manufacture duct in lengths to accommodate installation of duct liner.

3.2 DUCT LINER

- .1 Install in accordance with manufacturer's recommendations, recommendations of SMACNA, and as follows:
 - 1 Fasten to interior sheet metal surface with 100% coverage of adhesive.
 - 2 In addition to adhesive, install weld pins at one pin per 2 sq. m (20 sq. ft) of liner, but not less than one row per side.

3.3 JOINTS

- .1 Seal all joints, exposed edges, weld pin and clip penetrations and all damaged areas of liner with joint tape. Badly damaged areas of lining shall be replaced at discretion of the Consultant.
- .4 Seal joint tape in accordance with manufacturer's recommendations, recommendations of SMACNA, and as follows:
 - 1 Bed tape in sealer.
 - 2 Apply two coats of sealer over tape.
- .5 Protect leading and trailing edges with sheet metal edging.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 Provide all grilles, registers, diffusers and accessories.
- .2 Grilles, registers and diffusers shall be the product of one manufacturer.

1.2 SHOP DRAWINGS AND PRODUCT DATA

- .1 Submit Shop Drawings in accordance with Section 21 05 01.

1.3 SAMPLES

- .1 Samples are required for each type of grille, register and diffuser.

1.4 CERTIFICATION OF RATINGS

- .1 Catalogued or published ratings shall be those obtained from tests carried out by manufacturer or those ordered by the manufacturer from independent testing agency indicating adherence to ASHRAE and SMACNA codes and standards.

PART 2 - PRODUCTS

2.1 GENERAL

- .1 Provide standard product to meet capacity, throw, noise level, throat and outlet velocity.
- .2 Where grilles, registers and diffusers penetrate fire walls and fire partitions, provide approved steel sleeve secured to structure in accordance with NFPA 90A.
- .3 Frames:
 - .1 Steel: prime coated cold rolled steel with exposed welded joints and mitred corners.
 - .2 Aluminum: extruded satin finish with mechanical fasteners and mitred corners.
 - .3 Provide full perimeter gaskets.
 - .4 Provide plaster frames as plaster stops where set into plaster or gypsum board.
 - .5 Provide concealed fasteners and operators.
- .4 Sizes and capacities as indicated in Schedules provided on the Drawings.
- .5 Floor grilles to be capable of supporting 90 kg (200 lbs) point load weight between supports with negligible deflection.

PART 3 - EXECUTION

3.1 INSTALLATION

- .1 Install in accordance with manufacturer's instructions.
- .2 Install with flat head cadmium plated screws in countersunk holes where fastenings are visible.

END OF SECTION

PART 1 - GENERAL

1.1 WORK INCLUDED

- .1 This document outlines the minimum equipment and performance standards for a completely interoperable Building Automation System (BAS).
- .2 The work shall include design, supply, installation, and commissioning a complete microprocessor based automatic control system to achieve the performance specified in the following Sections.
- .3 The BAS shall be supplied and installed by a controls vendor familiar with the system installed at base building by Delta Controls.
- .4 The BAS shall be capable of total integration of facility infrastructure systems with user access to all system data, either locally over a secure Intranet within the building or by remote access by a standard Web Browser over the Internet.
- .3 The entire BAS shall be peer-to-peer networked, stand-alone, distributed control in accordance with American National Standards Institute/American Society of Heating, Refrigerating and Air Conditioning Engineers (ANSI/ASHRAE) Standard 135-2004, BACnet – A Data Communication Protocol for Building Automation and Control Networks.
- .4 All labour, material, equipment and software not specifically referred to herein or on the plans, but is required to meet the functional intent, shall be provided without additional cost to the Owner.
- .5 The Contractor shall ensure that the BAS Subcontractor will provide the necessary engineering, installation, supervision, commissioning and programming for a complete and fully operational system. The Contractor will provide as many trips to the job site for installation, supervision, and commissioning as are necessary to complete the project to the satisfaction of the Consultant and/or project supervisor.

The Contractor shall ensure that the BAS Subcontractor will specifically read all mechanical and electrical Drawings, specifications, and addenda and determine the controls work provided by other forces under the Contract, including the mechanical Subcontractor, and the electrical Subcontractor. The Contractor shall ensure the controls Subcontractor has the expertise to coordinate the work of other Subcontractors (electrical, mechanical, general trades, etc.) and to make a completely coordinated Building Automation Control System (BAS) for the mechanical systems.

- .6 The BAS shall be compatible with future control Products for 10 years or more.
 - .7 Ensure compliance with all applicable codes and requirements of Authorities Having Jurisdiction, including but not limited to plans examiner, building inspector, etc.
 - .8 Ensure the system shall be installed by trade certified electricians regularly employed by the BAS Subcontractor. The system shall be tested and calibrated by factory certified technicians qualified for this type of work and in the regular employment of the BAS Subcontractor or its exclusive factory authorized installing contracting field office representative. The installing office shall have a minimum of five years of installation experience with the manufacturer. Ensure supervision, calibration and commissioning of the system shall be by the BAS Subcontractor.
-

- .9 Refer to the instructions to bidders for the bidders' meeting scheduled prior to the tender closing date to become familiar with field conditions and existing equipment.

1.2 SCOPE

- .1 Preparation of control Shop Drawings for review and approval. See Section 1.3 Submittals.
- .2 Supply and install a network of Building Automation Control System (BAS) panels and field devices.
- .3 Supply and install customized graphics software as specified.
- .4 Install, wire and label all BAS control system components.
- .5 Calibrate and commission the installed control system.
- .6 Provide maintenance manuals and as-built drawings.
- .7 Provide customized training for operations, maintenance and technical staff.
- .8 Provide complete point-to-point commissioning testing, and submit commissioning report to Commissioning Agent and Consultant prior to Commissioning Functional Testing.
- .9 Provide complete updating of existing graphical user interface to indicate all new control point and equipment locations. Graphical interface shall include floor plans with actual locations of wallfin radiators, control valves, temperature sensors, fan coil units, etc.

3.2 SUBMITTALS

- .1 Submit Shop Drawings in accordance with Section 21 05 01 and include the following:
- Control Schematics.
 - Detailed sequence of operation for each control schematic or controlled system.
 - System Architecture indicating the proposed interconnection and location of all BAS panels, network connections and key peripheral devices (workstations, modems, printers, repeaters, etc.)
 - BAS Points List indicating the panel Identification (ID), panel location, hardware address, point acronym, point description, field device type, point type (i.e., AO/DO/AI/DI), end device fail position, end device manufacture and model number, and wire tag ID). Terminal identification for all control wiring shall be shown on the shop drawings.
 - Wiring diagrams including complete power system, interlocks, control and data communications.
 - Hard copy graphical depiction of the application control programs.
 - Manufacturers' data / specification sheets for all material supplied.
- .2 Provide data for inclusion in the Operating and Maintenance Manuals in accordance with Section 21 05 01.

3.3 TRAINING

- .1 Training and technical support shall be provided to the Owner's designated representative which will cover the complete operation of the Building Control System ("BCS") and the software procedures to allow the user to add, modify or create points, Direct Digital Control ("DDC") loops or energy management programmes.
- .2 The duration of the training and technical support period shall be not less than eight (8) hours, conducted during normal working hours (i.e. 8.00 a.m. to 4.30 p.m., Monday through Friday). The instruction shall consist of both hands-on and classroom training.

3.4 MANUFACTURER CERTIFICATION

- .1 Provide manufacturer certification of the installation in accordance with Section 21 05 01

PART 2 - PRODUCTS

2.1 AUTOMATIC CONTROL VALVES AND OPERATORS

- .1 All characteristics of control valves shall be suitable for the required operation.
- .2 Straight through water valves shall be single seated with equal percentage flow characteristics.
- .3 Three-way mixing valves shall be linear for each port giving constant total flow.
- .4 All valves shall have stainless steel stems and spring loaded teflon cone packing.
- .5 Valves 50 mm (2") and smaller shall have screwed bodies. Valves 65 mm (2-1/2") and larger shall have flanged cast iron bodies.
- .6 The maximum pressure drop across any control valves shall not exceed 21 kPa (3 psi) unless specified otherwise in the Contract Documents.
- .7 Valve to have the following characteristics based on application:

Application	Valve Type (≤2")	Valve Type (2"+)	Spring Return	Control Signal
Fan Coil Unit (FCU) Cooling Coil	Globe or Characterized ball	Globe	No	Modulation
Radiator Heating Valve	Globe or Characterized ball	Globe	Yes	Modulation

2.2 THERMOWELLS

- .1 Thermowells shall be installed under section 23 05 10. Coordinate the requirements of this Section fully with section 23 05 10 and provide all required locations of thermowells for installation. The Contractor shall be responsible for all costs associated with providing thermowells due to information not being provided in advance of piping installation.

2.3 FIELD SENSORS AND CONTROL DEVICES

- .1 Each control unit shall be directly connected to point devices as specified by the input/output summary and control drawings.

.2 Temperature Sensors

- .1 All mixed air sensors shall be thermistor type with a 25 ft. averaging element. Accuracy of the thermistor shall be +/- 0.2°C over a range of 0 to 100°C. Sensor utilizing discreet sensor distribution over the length are not acceptable.
- .2 All supply and return air sensors shall be thermistor type with nominal value of 10kOhm @ 25 degrees C. The sensor probe shall have a minimum length of 8". The accuracy of the sensor shall be +/- 0.2°C over a range of 0 to 100°C.

Temperature sensors utilized for wall mounting in occupied spaces will be mounted in a white plastic enclosure. The size of the enclosure will not exceed 127 mm Width x 83 mm Height x 25 mm Diameter. The sensor will have a set-point and override push button. The sensor will have a service port to connect a laptop computer. The range shall be 4 to 37°C.

- .3 All liquid immersed sensors shall be thermistor type with nominal value of 10kOhm @ 25C. Strap-on temperature sensors are not acceptable. Each sensor shall be provided with a well suitable for the working temperature and pressure of the fluid. The accuracy of the sensor shall be +/- 0.2°C over a range of 20 to 80°C, 0 to 100°C or 50 to 150°C to suit application. Provide brass wells for copper pipe and stainless-steel wells for steel pipe.
- .4 Outdoor air sensors shall be the thermistor type with nominal value of 10kOhm @ 25C mounted in a weatherproof enclosure. The accuracy of the sensor shall be +/- 0.2°C over a range of -40 to 60°C.

.3 Room Multi-Sensor Hub

1. The Sensor hub shall measure space temperature at the occupant location and height within the room. Alternatively, provide multiple pendant mounted temperature sensors in each room in addition to the wall-mounted temperature sensors shown. The sensor array shall measure or sense:
- a. The average space temperature at 5' above the finished floor in an area 10' in diameter
 - b. Relative humidity in the room
 - c. Dry bulb temperature in the air surrounding the Sensor Hub
 - d. Motion in the space using passive infrared sensing
 - e. Sound levels in room
 - f. Lighting intensity
2. Based on measured and sensed conditions, the Sensor Hub will provide the following:
- a. Aggregate value for space temperature based on analytics and fusion of multiple sensors to within +/- 0.5 C accuracy
 - b. Aggregate values for room occupancy based on analytics and fusion of multiple sensors
 - c. Light intensity in foot-candles or lux
 - d. Light color in Red, Green, Blue (RGB) values or in degrees Kelvin (color temperature)
3. The sensor hub shall include an EnOcean or Equivalent access point in rooms as per the Drawings
-

4. The audio information shall not be recorded or stored in any way.

2.4 PANELS

- .1 Control panels shall be sprinkler resistant cabinets with all steel construction. Cabinets shall have hinged door with lock. All cabinet locks shall be common keyed.
- .2 Panels shall be wall mounted and shall be located in mechanical and electrical rooms.
- .3 Locate all control components except control units within control panels.
- .4 Each enclosure housing electronic equipment shall have a standard duplex AC power receptacle located within the enclosure to provide power for test equipment.
 - .1 All wiring internal to panel shall be in conduit or other plastic raceway.
 - .2 All field wiring shall terminate at a terminal strip. Wiring from terminal strip to controller shall be numbered and colour coded.

2.5 SYSTEM ARCHITECTURE AND COMMUNICATIONS

- .1 The BCS shall consist of intelligent microprocessor based control units interconnected by local area networks.
- .2 The system shall include three types of control units:
 - .1 Network control unit.
 - .2 System control unit.
 - .3 Terminal control unit.
 - .4 Integrated Room control unit
- .3 Systems utilizing control units incorporating functionality of more than one type are acceptable provided that all capabilities and flexibility specified in the Contract Documents are maintained.
- .4 Interface with and connect all new graphics, monitoring and control functions to the existing personal computer (PC) system central supervisory workstations.
- .5 Each Network, System, and Integrated Room control unit shall communicate by BACnet ethernet and/or BACnet IP protocols via ethernet port(s)
- .6 Each Network, System, and Terminal control units shall have capability to communicate by BACnet MS/TP via a RS-485 port
- .7 Operator interface to the system shall be through the PC workstations and each network control unit. All of these locations shall provide access to the complete system.

2.6 CONTROL UNITS - GENERAL

- .1 Each control unit shall be capable of full operation either as a completely independent unit or as part of the building-wide control system. All units shall contain the necessary equipment for direct interface to the sensors and actuators connected to it. Provide the necessary quantity of control units to accomplish the requirements of this Specification.
 - .2 Controllers shall be loaded to a maximum of 90%. 10% of inputs and outputs shall remain unused for future expansion.
 - .3 Each control unit shall include its own microprocessor controller, power supply, input/output modules, termination modules and real time clock/calendar.
 - .4 Each control unit shall be capable of direct interface to a variety of industry standard sensors and input devices.
 - .1 It shall be possible for each control unit to monitor the following types of inputs:
 - .1 Analog Inputs (AI)
 - .1 4 - 20 mA
 - .2 Thermistors
 - .3 0 - 10 VDC
 - .2 Digital Inputs (DI)
 - .2 The control unit shall directly control electronic actuators and control devices. Each control unit shall be capable of providing the following control outputs:
 - .1 Digital Output (DO),.
 - .2 Analog Outputs (AO)
 - .1 0 - 10 VDC
 - .3 Each digital output shall have an associated LED mounted within the control unit enclosure to indicate whether the DO relay is in the energized or de-energized position.
 - .5 Any point connected to the control unit shall be assignable to any energy management programme in a networked system.
 - .6 It shall be possible to fully create, modify or remove control algorithms within a specific control unit while it is operating and performing other control functions.
 - .7 The control unit shall contain all software necessary to maintain control of and monitor all points physically connected to it.
 - .8 Operating System
 - .1 A real time operating system shall be provided which shall include software to operate, manage and communicate to all peripheral devices.
-

- .2 Upon restoration of power, the operating system software shall ensure that the control unit resumes full operation without operator intervention. The control unit shall automatically reset its clock such that the proper operation of any time dependent function will occur without manual reset. All monitored functions shall be updated.
- .3 Should a loss of power exceed battery back-up, the operating system software shall be able to restore the most current versions of all energy management control programmes, direct digital control programmes, data base parameters, and all other data and programmes stored in the RAM of each control unit by downloading from the central computer system.
- .4 The operating system shall include self diagnostic software that shall continuously monitor the operation of the control unit. A control unit that is malfunctioning shall annunciate throughout the system indicating the nature of the malfunction and the control unit affected.
- .5 Point Database
 - .1 The control unit software shall have the capability to define each point in the point database and be capable of providing on-line access to the point data base, and on-line editing of the point data base while the system is functioning.
 - .2 Each point shall have an alphanumeric acronym assigned to it by which it may be referenced for use in any software module or applications programme in the system.
 - .3 The user editing capabilities of the point database shall be totally accomplished from any operator communication device.
 - .4 The operator, without assist from the BAS Subcontractor shall be able to add, delete and modify all points within the point database.
- .6 Direct Digital Control (DDC) Software
 - .1 The control unit shall contain DDC software that can be assigned to every analog or digital output point.
 - .2 The DDC software shall have the capability to be linked to any event or energy management programmes.
 - .3 The DDC software shall contain all the control functions required to perform the specified sequence of operation, including but not limited to the following:
 - .1 Proportional, integral and derivative control.
 - .2 On-Off dead band or floating control.
 - .3 Sequencing and cascading.
 - .4 Interlocks.
 - .5 Calculations.
 - .6 Boolean Algebra statements.

- .7 Time delays.
- .4 All DDC functions shall be written in an English language format using a BASIC type software language.
- .5 The building operator shall have the capability of adjusting any DDC parameters while the control unit is online.
- .9 All controllers shall be capable of operation in any environment that ranges from 32°F to 122°F, with 0% to 90% Relative Humidity (“RH”). The controllers should meet industry standards UL-864 and IEEE-472, if application requires as such as determined by the Consultant.
- .10 Input/Output Support
 - .1 Digital to analog and analog to digital conversion precision within the controller shall provide a minimum of 10 bits accuracy.

2.7 NETWORK CONTROL UNITS

- .1 Provide network control units in each mechanical room and as necessary to provide a complete communications system.
- .2 The Network control unit shall have a BACnet Ethernet and BACnet IP communication port for communication with Controllers and Operator Workstations at 10 Mbauds, minimum. The Ethernet port must conform to ISO 8802.3. Communication media shall be 10BaseT. Each Controller shall have diagnostic LEDs for the Ethernet communication port. Each Controller shall be addressable via “DIP SWITCH”.
- .3 The Network control shall support two MS/TP (RS485) BACnet communication ports for communication with terminal control units. These networks shall operate at 76800 bauds. The network speed shall be adjustable from 9600 to 76800 bauds. Each Controller shall have diagnostic LEDs for the MS/TP (RS485) communication port.
- .4 The network control unit shall support up to 99 terminal control units.
- .5 Network control unit shall permit up to 255 points to be shared between control units.
- .6 Provide preprogrammed energy management software that requires only operator configuration for the following:
 - .1 Time of day scheduling complete with holidays.
 - .2 Duty cycling with temperature compensation.
 - .3 Start/Stop optimization.
 - .4 Electrical demand limiting.
- .7 Provide rechargeable battery backup or super capacitor to maintain program entries, clock and all stored data for minimum seventy-two (72) hours. On restoration of power, Network Control Units shall load its program from built-in flash drive, if battery/capacitor backup has failed.

- .8 The controller shall be BTL listed.
- .9 Operator/System Communication
 - .1 Each control unit shall contain all software necessary for operator/system communication. This software shall permit full operator communication including as a minimum:
 - .1 Obtaining information about the performance of the system.
 - .2 Allowing the operator to add, modify or delete point data or programs.
 - .3 Diagnosing system malfunctions.
 - .4 Execution of Report Software as defined in this Specification.
 - .5 Execution of Alarm and Monitoring Software as defined in this Specification.
 - .6 Execution of User Programming Software, Energy Management and Direct Digital Control Software as defined in this Specification.
 - .2 Provide five-level password protection:
 - .1 Level One: Data Access and Display
 - .2 Level Two: Level One plus Operator Overrides
 - .3 Level Three: Level Two plus Database Modification
 - .4 Level Four: Level Three plus Database Generation
 - .5 Level Five: Level Four plus Password Add/Modification
 - .3 It shall be possible for passwords to be defined by the system manager while the system is on-line and fully operational.
 - .4 All operator communication shall be by full English language commands and prompts.
- .10 Monitoring and Control
 - .1 The operator shall be able to obtain information on all the system functions including point status or value, runtimes, setpoints, energy management parameters, and database elements. All information displayed shall use full English words and numerical values in floating point notation.
 - .2 Upon selection of any command point, the operator may change the point's binary state (START/STOP/AUTO) by actuating a single dedicated function key on the keyboard. Failure of the command to execute, as detected by a proof of operation status input, shall result in an alarm condition providing that no higher priority control action is in progress superseding the manual command. All manual, program or event commands competing for control of a start/stop binary point shall be prioritized with the highest level taking control until released to the next lower command state. Provide sixteen (16) priority levels which may be displayed with their current status for each logical two (2) or three (3) state command point in the system.

Setpoints for analog control points and Proportional, Integral, Derivative ("PID") loops shall be changed by selecting the point (and its setpoint entry element) and typing in its new setpoint value for manual setpoint control.

.3 All start/stop and status points shall accumulate runtime.

.11 Report Software

.1 Provide software to produce reports in pre-defined format. All of the reports and logs specified in this Section shall be provided in a "ready to use" state. Documentation for operator use of these reports shall include specific examples of how to institute and interpret the reports.

.2 The functional operation of the control unit shall not be affected by report display or printing.

.3 All reports and logs shall include the date and time of report initiation, the name of the report, and row and column headings with all units clearly labelled.

.4 All reports and logs shall be attainable on a per point basis or on a user defined group of points. Groups of points shall be logically combined without regard to the hardware physical location.

.5 As a minimum, the following control unit report summaries shall be provided:

.1 All point summary.

.2 Group summary.

.3 Status summary.

.4 Alarm summary.

.5 Analog alarm limit summary.

.6 Locked out points summary.

.7 Message summary.

.8 DC programme listing.

.9 Historical trend report.

.10 Totalization report.

2.8 SYSTEM CONTROL UNITS

.1 Provide standalone system control units as required to implement the specified control functions. Provide one system control unit for each supply air system and each water system.

.2 All input/output points associated with a physical system shall be directly connected to the system control unit. Provide control units with input/output configurations to meet specific application requirements.

.3 System control units shall be fully user programmable via the associated network control unit.

- .4 The system control unit shall have a BACnet Ethernet and BACnet IP communication port for communication with Controllers and Operator Workstations at 10 Mbauds. The Ethernet port must conform to ISO 8802.3. Communication media shall be 10BaseT. Each Controller shall have diagnostic LEDs for the Ethernet communication port. Each Controller shall be addressable via "DIP SWITCH".
- .5 Each System control unit shall include an integral real time clock/calendar.
- .6 Provide rechargeable battery backup or super capacitor to maintain program entries, clock and all stored data for minimum seventy-two (72) hours. On restoration of power, System control units shall load its program from built-in flash drive, if battery/capacitor backup has failed.
- .7 Provide the following software capabilities for each system control unit:
 - .1 Proportional, Integral, Derivative (PID) control.
 - .2 Temperature compensated duty cycling.
 - .3 Self-diagnostics.
 - .4 Start/Stop optimization.
 - .5 Programmable logic control.
 - .6 Enthalpy control.
 - .7 Time of day scheduling.
 - .8 Power failure restart.
 - .9 User defined programming.
- .8 Provide lockable metal enclosure suitable for wall mounting or locate within control panels.
- .9 Controller shall support the use of a user friendly handheld or panel mounted interface unit. This unit will display a graphic of the system being controlled, store alarms, and have audible/visual alarm indicator. Provide display unit as noted on points listed.
- .10 The controller shall be BTL listed.

2.9 TERMINAL CONTROL UNITS

- .1 Provide standalone application specific control units for all terminal units where indicated in the Contract Documents.
- .2 Terminal control units shall include preprogrammed control sequences requiring only configuration or be fully programmable based on application. The database shall be maintained in non-volatile Flash drive memory.
- .3 Provide the following software capabilities for each terminal control unit:

- .1 PID space temperature control.
- .2 Self-diagnostics.
- .3 Power failure restart.
- .4 Provide outputs for damper operator, control valves and fan control as required for each application. Where necessary, provide control relays to interface between control units and fan circuit.
- .5 Provide local communication jack at controller.
- .6 The terminal control shall support a MS/TP (RS485) communication port. These networks shall operate at 76800 bauds. The network speed shall be adjustable from 9600 to 76800 bauds. Each controller shall have diagnostic LEDs for the MS/TP (RS485) communication port.
- .7 Provide rechargeable battery backup or super capacitor to maintain program entries, clock and all stored data for minimum seventy-two (72) hours. On restoration of power, System control units shall load its program from built-in flash drive, if battery/capacitor backup has failed.
- .8 The controller shall be BTL listed.

2.10 INTEGRATED ROOM CONTROL UNITS

- .1 Provide standalone programmable control units as required to implement the specified control functions.
- .2 All input/output points associated with a physical system shall be directly connected to the programmable control unit. Provide control units with input/output configurations to meet specific application requirements.
- .3 Programmable control units shall be fully user programmable via the associated network control unit.
- .4 The controller shall be a Deutsche Institut für Normung (DIN) rail mounted, BTL listed BACnet Rev 14 or greater Advanced Application Controller.
- .5 The controller must have dual port Ethernet that allows 'daisy chained' network connectivity.
- .6 The controller shall be expandable to include the modules that are needed for the automation of the space.
- .7 Controller universal I/O shall be fully software configured and defined as either input or output, and shall support input types of 10K, 0-5V, 0-10V, or 4-20mA, and outputs of 0-10V sourcing or 1-10V sinking current modes, so as to include support for control of dimmable lighting ballasts.
- .8 Each programmable control unit shall include an integral real time clock/calendar.
- .9 Provide rechargeable battery backup or super capacitor to maintain program entries, clock and all stored data for minimum seventy-two (72) hours. On restoration of power, System control units shall load its program from built-in flash drive, if battery/capacitor backup has failed.
- .10 Provide the following software capabilities for each programmable control unit:

- .1 PID control.
- .2 Temperature compensated duty cycling.
- .3 Self-diagnostics.
- .4 Start/Stop optimization.
- .5 Programmable logic control.
- .6 Enthalpy control.
- .7 Time of day scheduling.
- .8 Power failure restart.
- .9 User defined programming.
- .11 Provide lockable metal enclosure suitable for wall mounting or locate within control panels.
- .12 Controller shall support the use of a user friendly handheld or panel mounted interface unit. This unit will display a graphic of the system being controlled, store alarms, and have audible/visual alarm indicator. Provide display unit as noted on points listed.

2.11 CENTRAL COMPUTER SYSTEM HARDWARE

- .1 Terminal unit controllers shall support the use of a user friendly handheld or panel mounted interface unit. This unit shall directly connect to the controller through the room sensor jack, or directly at the controllers communications jack. Provide one handheld display and instruct building maintenance on use.

PART 3 - EXECUTION

3.1 POWER AND CONTROL WIRING

- .1 Provide all necessary conduit, fittings and wire to provide a complete control system described in this Specification. Power and Control wiring shall be installed in EMT conduit. Plenum cable is not acceptable.
- .2 Provide power to control panels from the nearest electrical panel. Power for control system shall **not** be obtained by tapping into miscellaneous circuits that could be inadvertently switched off. Only dedicated circuit(s) shall power the control system. Provide additional breakers or electrical panels as required.

3.2 IDENTIFICATION

- .1 Provide engraved lamacoid nameplate clearly indicating the service and designation for the following devices. The nameplate for any device being controlled by the Energy Management Control System ("EMCS") shall also include the EMCS point name and the designation of the control panel which serves

the device.

- .1 Duct and pipe mounted sensors.
- .2 Electronic control panels.
- .3 Manual switches.
- .4 Thermostats in unfinished areas.
- .5 Control valves.
- .6 Damper operators.
- .2 All wiring shall be identified with permanent numbered wire markers cross referenced to wiring diagrams.

3.3 CONTROL UNITS

- .1 Locate control units to be accessible for service and replacement.
- .2 Provide power from nearest electrical panel. Provide all transformers necessary to power control units, actuators and other system components.
- .3 Network Control Units
- .4 Locate network control units within spaces shown on the Drawings. Confirm exact location with Consultant.
- .5 Mount units with operator interface at level convenient for viewing and operation.
- .6 Programmable Control Units
- .7 Locate programmable control units adjacent to equipment served.
- .8 Programmable control units shall not be mounted on mechanical or electrical equipment.
- .9 The Contractor shall co-ordinate with heat pump manufacturer and provide commissioning.

3.4 PROGRAMMING

- .1 Provide all programming necessary for a fully functioning system.
 - .2 The control strategy for each system shall be performed by software within the control unit. Refer to the Control Drawings for the sequence of operation for each system.
 - .3 Tune each temperature control loop to provide control within $\pm 1^{\circ}\text{F}$ unless otherwise indicated in the Contract Documents.
 - .4 Provide time schedules for all start/stop points.
 - .5 Provide high and low limit alarms on all analog input points.
 - .6 Program the level of annunciation for each alarm to the requirements of the Owner
- .1 Local to specific network control unit(s).
 - .2 PC Workstations.

3.5 DEMONSTRATION AND TESTING

- .1 Submit a schedule of testing for each system, sample checklist and description of tests for review by the Consultant.
- .2 Provide detailed testing of each system prior to review by the Consultant. Submit a checklist, by system, indicating that all connected points and programming have been verified as specified herein.

- .3 The BCS will not be considered substantially complete until all specified points are connected to the system and testing has been completed.
- .4 All digital input alarm points (eg. high level, low pressure, etc.) shall be tested by physically simulating an alarm condition.
- .5 Start/stop points shall be verified by physical inspection.
- .6 All temperature, humidity and pressure sensors shall be calibrated using accurate electronic testing equipment as a reference.
- .7 All control loops and programmed sequences of operation shall be verified by simulating conditions for each mode of operation.
- .8 Provide demonstration of each system to the Consultant and the Owner when testing is completed. The purpose of this demonstration is to verify that testing has been successfully completed.

3.6 OWNER'S INSTRUCTION

- .1 Provide instruction to the Owner's representatives with respect to operation and maintenance of the BCS. This is not part of training as specified below.
- .2 Explain the operation of each device including normal operating conditions, emergency procedures and maintenance requirements.
- .3 Indicate, by physical inspection, the location of all control devices within mechanical and other service rooms.
- .4 Demonstrate procedures for adjusting and calibrating thermostats, controllers and sensors. Demonstrate all manual override capabilities of the system.

3.7 POINT-TO-POINT COMMISSIONING

- .1 Provide complete point-to-point commissioning testing, and submit commissioning report to Commissioning Agent and Consultant prior to Commissioning Functional Testing.

END OF SECTION

PART 1 – GENERAL

1.1 General

- .1 The purpose of this section is to specify Division 25 responsibilities in the commissioning process for the work of Division 23.
- .2 The systems to be commissioned are listed in Section 01 91 00 subsection 1.9. The abbreviations and definitions used in Section 01 91 00 apply to this Section 23 08 00 – HVAC System Commissioning.
- .3 Commissioning shall take into account the requirements under Division 25 to ensure that all systems are operating in a manner consistent with the Contract Documents. The general commissioning requirements and coordination are detailed in Section 01 91 00. For the purposes of completing work under Division 25 shall be familiar with all parts of Section 01 91 00 and the commissioning plan issued by the CA and shall execute all commissioning responsibilities assigned to them in the Contract Documents.

1.2 Responsibilities

- .1 Controls Subcontractor. The responsibilities of the Contractor and its Controls Subcontractor, during construction and acceptance phases in addition to those listed above are (all references apply to commissioned equipment only):
 - .1 Sequences of Operation Submittals. The Controls Contractor's submittals of control drawings shall include complete detailed sequences of operation for each piece of equipment, regardless of the completeness and clarity of the sequences in the specifications. They shall include:
 - .1 An overview narrative of the system (1 or 2 paragraphs) generally describing its purpose, components and function.
 - .2 All interactions and interlocks with other systems.
 - .3 Detailed delineation of control between any packaged controls and the BAS, listing what points the BAS monitors only and what BAS points are control points and are adjustable.
 - .4 Written sequences of control for packaged controlled equipment. (Equipment manufacturers' stock sequences may be included but will generally require additional narrative).
 - .5 Start-up sequences.
 - .6 Warm-up mode sequences.
 - .7 Normal operating mode sequences.
 - .8 Unoccupied mode sequences.
 - .9 Shutdown sequences.
 - .10 Capacity control sequences and equipment staging.
 - .11 Temperature and pressure control: setbacks, setups, resets, etc.
 - .12 Detailed sequences for all control strategies, e.g., economizer control, optimum start/stop, staging, optimization, demand limiting, etc.
 - .13 Effects of power or equipment failure with all standby component functions.
 - .14 Sequences for all alarms and emergency shut downs.
 - .15 Seasonal operational differences and recommendations.

- .16 Initial setpoints and recommended values for all adjustable settings, setpoints and parameters that are typically set or adjusted by operating staff; and any other control settings or fixed values, delays, etc. that will be useful during testing and operating the equipment.
- .17 Schedules, if known.
- .18 To Facilitate referencing in testing procedures, all sequences shall be written in concise statements.
- .2 Control Drawings Submittal
 - .1 The control drawings shall have a key to all abbreviations.
 - .2 The control drawings shall contain graphic schematic depictions of the systems and each component (i.e. sensors, dampers, coils, valves, etc.)
 - .3 The schematics will include the system and component layout of any equipment that the control system monitors, enables or controls, even if the equipment is primarily controlled by packaged or integral controls.
 - .4 Provide a full points list with at least the following included for each point:
 - .1 Controlled system
 - .2 Point abbreviation
 - .3 Point description
 - .4 Display unit
 - .5 Control point or setpoint (Yes / No)
 - .6 Monitoring point (Yes / No)
 - .7 Intermediate point (Yes / No)
 - .8 Calculated point (Yes / No)
 - .9 Key:
 - Point Description: DB temp, airflow, etc.
 - Control or Setpoint: Point that controls equipment and can have its setpoint changed (OSA, SAT, etc.)
 - Intermediate Point: Point whose value is used to make a calculation which then controls equipment (space temperatures that are averaged to a virtual point to control reset).
 - Monitoring Point: Point that does not control or contribute to the control of equipment, but is used for operation, maintenance, or performance verification.
 - Calculated Point: "Virtual" point generated from calculations of other point values.
- .3 As-Built Controls Package - An updated as-built version of the Controls Drawings and Sequence of Operation, which is to include all items identified above, shall be provided to the CA and included in the final controls O&M manual submittal.
- .4 Assist in TAB Work- Ensure the Controls Subcontractor shall assist in the TAB work through the following:

- .1 Meet with the TAB Subcontractor prior to beginning TAB and review the TAB plan to determine the capabilities of the control system toward completing TAB. Provide the TAB Subcontractor any needed unique instruments for setting terminal unit boxes and instruct the TAB Contractor in their use (handheld control system interface for use around the building during TAB, etc.).
- .2 For a given area, have all required prefunctional checklists, calibrations, startup and selected functional tests of the system completed and approved by the CA prior to TAB.
- .3 Provide a qualified technician with minimum 5 years of verifiable controls installation and programming experience to operate the controls to assist the TAB contractor in performing TAB, or provide sufficient training for TAB to operate the system without assistance.
- .5 Required assistance to the CA - Assist and cooperate with the CA in the following manner:
 - .1 Using a skilled technician who is familiar with the building, execute the functional testing of the all equipment specified in Section 01 91 00 under direction of the CA. Provide two-way radios during the testing.
 - .2 Execute all control system trend logs specified in Section 01 91 00.
 - .3 Written Plan – Ensure the Controls Subcontractor shall prepare a written plan indicating in a step-by-step manner, the procedures that will be followed to test, checkout and adjust the control system prior to functional performance testing, according to the process in Section 01 91 00. At minimum, the plan shall include the following for each type of equipment controlled by the automatic controls:
 - .1 System name.
 - .2 List of devices.
 - .3 Step-by-step procedures for testing each controller after installation, including:
 - .1 Process of verifying proper hardware and wiring installation.
 - .2 Process of downloading programs to local controllers and verifying that they are addressed correctly.
 - .3 Process of performing operational checks of each controlled component.
 - .4 Plan and process for calibrating valve and damper actuators and all sensors.
 - .5 A description of the expected field adjustments for transmitters, controllers and control actuators should control responses fall outside of expected values.
 - .4 A copy of the log and field checkout sheets that will document the process. This log must include a place for initial and final read values during calibration of each point and clearly indicate when a sensor or controller has “passed” and is operating within the contract parameters.
 - .5 A description of the instrumentation required for testing.
 - .6 Indicate what tests on what systems should be completed prior to TAB using the control system for TAB work. Coordinate with the CA and TAB Subcontractor for this determination.
- .6 Checkout Certification - Provide a signed and dated certification report to the CA and PM/GC upon completion of the checkout of each controlled device, equipment and system prior to functional testing. This report shall serve as confirmation that all system programming is complete in accordance to the Contract Documents, with the exception functional testing requirements. The checkout report shall also include complete point-to-point verification and sequence of operations verification checklists.

- .7 List and clearly identify on the as-built duct and piping drawings the locations of all static and differential pressure sensors (air, water and building pressure).

PART 2- PRODUCTS

- .1 NOT USED

PART 3- EXECUTION

3.1 Submittals

- .1 Provide submittal documentation relative to commissioning to the CA as requested by the CA. Refer to Section 01 91 00 Part 3.3 for additional Section 25 requirements.

3.2 Start-up of Equipment

- .1 Follow the start-up and initial checkout procedures listed in the Responsibilities list in this section and in Section 01 91 00, Part 3.4. Ensure the start-up responsibility under Division 21 is met has start-up responsibility and is required to complete systems and sub-systems so they are fully functional, meeting the design objectives of the Contract Documents. The commissioning procedures and functional testing do not relieve or lessen this responsibility or shift that responsibility partially to the CA or Owner.
- .2 Functional testing is intended to begin upon completion of a system. Functional testing may proceed prior to the completion of systems or sub-systems at the discretion of the CA and CM. Beginning system testing before full completion does not relieve the Contractor from fully completing the system, including all pre functional checklists as soon as possible.
- .3 Prior to the start up of equipment under Division 21 the Contractor shall arrange to have the manufacturer of all major equipment inspect the installation to ensure their equipment has been installed in accordance with their recommendations.
- .4 The manufacturer shall submit a written report of their findings.
- .5 Upon confirmation that the equipment has been installed in accordance with the Manufacturers Recommendations the equipment may be started.
- .6 All equipment shall be started by the manufacturer's representative.

3.3 Pre-Functional Test Sheets

- .1 Pre-functional test sheets contain items to be performed under Division 25. On each checklist, a column is provided that is to be completed by the contractor assigning responsibility for that line item to a trade. Those executing the test sheets are only responsible to perform items that apply to the specific application at hand. These test sheets do not take the place of the manufacturer's recommended checkout and start-up procedures or report. Some checklist procedures may be redundant in relation to checkout procedures that will be documented on typical factory field checkout sheets. Double documenting may be required in those cases.

- .2 Refer to Section 01 91 00 for additional requirements regarding pre-functional test sheets, startup and initial checkout. Items that do not apply should be noted along with the reasons on the checklist. If this checklist is not used for documenting, one of similar rigor and clarity shall be used pending approval from the CA. Contractor's assigned responsibility for sections of the checklist shall be responsible to see that checklist items by their subcontractors are completed and checked off. "Contr." column or abbreviations in brackets to the right of an item refer to the contractor responsible to verify completion of this item. A/E = Architect/Engineer, All = Contractor including all Subcontractors, CA = Commissioning Agent, CC = Controls Subcontractor, EC = Electrical Subcontractor, PM/GC = General Contractor, MC = Mechanical Subcontractor, SC = Sheet Metal Subcontractor, TAB = Test and Balance Subcontractor.

3.4 Operations and Maintenance Manuals

- .1 Compile and prepare documentation for all equipment and systems covered in Division 25 and deliver to the GC for inclusion in the O&M manuals
- .2 The CA shall receive a copy of the O&M manuals for review.

3.5 Training of Owner Personnel

- .1 The GC shall be responsible for training coordination and scheduling and ultimately to ensure that training is completed. Refer to Section 01 91 00 for additional details.
- .2 The CA shall be responsible for overseeing and approving the content and adequacy of the training of Owner personnel for commissioned equipment. Refer to Section 01 91 00 for additional details.
- .3 Controls Subcontractor. The controls contractor shall have the following training responsibilities:
 - .1 Provide the CA with a training plan two weeks before the planned training according to the outline described in Section 01 91 00, Part 3.8.
 - .2 Provide designated Owner personnel with comprehensive training in the understanding of the systems and the operation and maintenance of the BAS system.
 - .3 Training shall start with classroom sessions, if necessary, followed by hands on training on the BAS, which shall illustrate the various modes of operation, including startup, shutdown, fire/smoke alarm, power failure, etc.
 - .4 During any demonstration, should the system fail to perform in accordance with the requirements of the O&M manual or sequence of operations, the system will be repaired or adjusted as necessary and the demonstration repeated.
 - .5 The training sessions shall follow the outline in the Table of Contents of the operation and maintenance manual and illustrate whenever possible the use of the O&M manuals for reference.
 - .6 Training shall include:
 - .1 Use the printed installation, operation and maintenance instruction material included in the O&M manuals.
 - .2 Include a review of the written O&M instructions emphasizing safe and proper operating requirements, preventative maintenance, special tools needed and spare parts inventory suggestions. The training shall include start-up, operation in all modes possible, shut-down, seasonal changeover and any emergency procedures.
 - .3 Discuss relevant health and safety issues and concerns.
 - .4 Discuss warranties and guarantees.

- .5 Cover common troubleshooting problems and solutions.
- .6 Explain information included in the O&M manuals and the location of all plans and manuals in the facility.
- .7 Discuss any peculiarities of equipment installation or operation.
- .8 Classroom sessions shall include the use of overhead projections, slides, video and audio taped material as might be appropriate.
- .7 Hands-on training shall include start-up, operation in all modes possible, including manual, shut-down and any emergency procedures and maintenance of all pieces of equipment.
- .8 Ensure the Controls Subcontractor shall fully explain and demonstrate the operation, function and overrides of any local packaged controls, not controlled by the central control system.
- .9 Training shall occur after functional testing is complete, unless approved otherwise by the Project Manager.

3.6 Deferred Testing

- .1 Refer to Section 01 91 00, Part 3.9 for requirements of deferred testing.

3.7 WRITTEN WORK PRODUCTS

- .1 Written work products under Division 25 shall consist of the start-up and initial checkout plan as described in Section 01 91 00, as well as completed start-up, initial checkout and pre-functional test sheets.

END OF SECTION